Orchard Tests For Apple Scab Control in New York State:

I. Sulfur Fungicides

By J. M. Hamilton and D. H. Palmiter

29 JAN 1952

NEW YORK STATE AGRICULTURAL
EXPERIMENT STATION
GENEVA, N. Y.

Bulletin No. 747 April, 1951

CONTENTS

	Page
Abstract	5
Introduction	5
Materials and methods	6
Spray materials	6
Preparation of sprays	8
Technic of applying sprays	8
Choice of plots	9
Weather records	9
Evaluation of primary inoculum	9
Methods of taking results	9
Experimental orchard tests	10
Relation of ascospore discharge to host development and number of infection periods	10
Relation of orchard conditions, carry-over of scab, and infection periods to spray treatments and results	11
1935 results	12
Hudson Valley	12
1936 results	14
Hudson Valley	14
1937 results	15
Western New York	15
Hudson Valley	17
1938 results	20
Western New York	20
Hudson Valley	20
1939 results	22
Western New York	22
Hudson Valley	23
1940 results	24
Western New York	24
Hudson Valley	26
1941 results	27
Hudson Valley	27
1942 results	28
Western New York	28
Hudson Valley	29
1943 results	32
Hudson Valley	32
1944 results	34
Hudson Valley	34
1945–1950 results	35
Western New York	36
Hudson Valley	37

Discussion and conclusions 37
Factors influencing choice of fungicide 37
Timing applications 37
Infection periods 39
Particle size 40
Minimal dosage 41
Adjuvants 41
Wettable sulfurs compared with lime-sulfur 44
Mixed fungicide programs 46
Status of fungicides at end of 1950 season 49
Summary 51
Literature cited 52
Appendix 55

A publication of the
New York State Agricultural Experiment Station
Geneva, N. Y.,
New York State College of Agriculture
A unit of the State University of New York
At Cornell University

Bulletin No. 747

Orchard Tests for Apple Scab Control in New York State:

I. Sulfur Fungicides[1]

J. M. HAMILTON and D. H. PALMITER

ABSTRACT

THE results of ten years of orchard testing (1935–44) of sulfur fungicides for apple scab control in New York State are given. The objective of the work was to establish the place of wettable sulfurs in the spray program and thereby eliminate the injury and reduction in yield caused by liquid lime-sulfur.

Factors influencing choice of fungicide, timing of applications, infection periods, particle size, minimal dosage, adjuvants, comparison of wettable sulfurs with lime-sulfur, and mixed fungicide programs are discussed as pertinent to the data.

A brief resume of the status of fungicides at the end of the 1950 season is given.

INTRODUCTION

DURING 1935 to 1944 progress reports on the relative effectiveness of various fungicides tested for apple scab control in the orchard and the factors involved were made at the annual meetings of the New York State Horticultural Society (1,3,7,8,9,10,11,14,16, 17,18,19,22,23).[2]

The final analysis of the merits of a fungicide can be made only after it has been tested over a period of years under varying climatic conditions. In seasons unfavorable for scab development, a comparatively ineffective material, even at a low concentration, may give control, particularly if the application is thorough and properly timed. The evaluation of a material at a practical concentration is determined by such factors as inherent toxicity, eradicative value, retention, redistribution, injury to host, and compatibility with insecticides. In other words, it is essential to have a complete picture of the performance of the spray material as determined by the inter-

[1]A bulletin on organic fungicides will follow as Part II.

[2]Figures in parenthesis refer to Literature Cited, page 52.

relationship of time of spraying, host development, and the infection period or climatic factors.

The main thesis of this bulletin is to substantiate further the use of wettable sulfurs. It seems proper to present the data collected during ten years in order to give a complete picture of what may take place over a period of time. It is a continuation of previously reported work covering the period 1930 to 1935 (2,4).

In the course of these orchard experiments, certain types of products have been tested throughout while others were discontinued because of injury, failure to give adequate control, manufacturing difficulties, or the introduction of new materials into the spray schedule. Of the many fungicides evaluated the better sulfur-containing materials alone have stood the test of time. Many of these products were improved from year to year before World War II, and at that time, some were changed with the scarcity of materials. Plots to determine the possibilities of copper fungicides for use in the cover sprays were included in many of these same orchards, particularly in western New York, but the data will not be presented in detail here due to the introduction of Fermate and DDT. Extensive field tests with organic fungicides began in 1939, but Fermate is the only material included in this publication.

MATERIALS AND METHODS

SPRAY MATERIALS

Lime-sulfur. — The standard, commercial, liquid concentrate testing 32° Baumé.

Dry lime-sulfur. — A dry form of lime-sulfur which contains sugar as a stabilizer. Prepared by the Sherwin-Williams Company, Cleveland, Ohio.

Koppers flotation sulfur paste. — Koppers paste is a thylox type of flotation sulfur containing about 40 to 45 per cent sulfur. Particle size is 2.5 microns with 76 per cent under 4 microns. Koppers Dry, a dried form containing 90 per cent sulfur, was tested in 1941 and 1942. Prepared as a by-product in the purification of manufactured gas by the Rochester Gas and Electric Co., Rochester, N. Y.

Everett flotation sulfur paste. — Everett paste is a 50 per cent Koppers thylox type of flotation sulfur. Prepared by the Boston Consolidated Gas Company, Boston, Mass.

Camden flotation sulfur paste. — Camden paste is a ferrox type of flotation sulfur containing 35 per cent sulfur. Camden Dry, a dry form, prepared by the Camden Coke Plant, Camden, N. J., was tested in 1937.

Hudson Valley flotation sulfur paste. — Hudson Valley paste is similar to Koppers paste except for the addition of glue. Samples used in 1938 to 1940 contained 40 per cent sulfur while those used from 1941 to 1944 contained 50 per cent sulfur. Prepared by the Hudson Valley Fuel Corp., Troy, N. Y.

Magnetic "70" sulfur paste. — Magnetic "70" paste is made by the "grinrod" process and contains 70 per cent sulfur. Particle size is 5.2 microns with 21 per cent under 4 microns. Prepared by the Stauffer Chemical Co., New York, N. Y.

Fungisul sulfur paste. — Fungisul is a wet ground, 70 per cent, sulfur paste with an average particle size of less than 2 microns. It is prepared by the United States Rubber Co., New York, N. Y.

Magnetic-Spray wettable sulfur. — Magnetic-Spray is a 98 per cent sulfur with a particle size 95 per cent by weight under 27 microns, 75 per cent under 15 microns, 50 per cent under 10 microns, or an average of 8.3 microns with 7 per cent under 4 microns. Prepared by the Stauffer Chemical Co., New York, N. Y.

Mulsoid wettable sulfur. — Mulsoid contains 95 per cent 325-mesh sulfur. Prepared by the Sherwin-Williams Co., Cleveland, Ohio.

Sulcoloid wettable sulfur. — Sulcoloid contains 93 per cent sulfur. Particle size is 14 microns with 1 per cent under 4 microns in 1936 to 1937 and 8.6 microns with 10 per cent under 4 microns in 1938 to 1943. Prepared by the Ansbacher-Siegle Corp., Brooklyn, N. Y.

Kolospray wettable sulfur. Kolospray, a mixture of hyperfine elemental sulfur and bentonite sulfur, contains 84 per cent sulfur. Particle size is 7.7 microns with 8 per cent under 4 microns. Prepared by the Niagara Chemical Division, Food Machinery & Chemical Corp., Middleport, N. Y.

Sulforon wettable sulfur. — Sulforon is a 98 per cent sulfur. Particle size is 6.6 microns with 11 per cent under 4 microns. Prepared by E. I. DuPont de Nemours & Co., Inc., Grasselli Chemicals Dept., Wilmington, Del.

Mike wettable sulfur. — Mike is made by the "grinrod" process and contains 95 per cent sulfur. Particle size is 5.3 microns with 21 per cent by weight under 4 microns. Prepared by the Dow Chemical Co., Midland, Mich.

Stauffer's Dry wettable sulfur. — Stauffer's Dry is dried Magnetic "70" paste. Particle size is 5.2 microns with 21 per cent by weight under 4 microns. Prepared by the Stauffer Chemical Co., New York, N. Y.

Micronized wettable sulfur. — Micronized contains 93 per cent micronized sulfur. Particle size is 3.6 microns with 47 per cent by weight under 4 microns. Prepared by the Micronizer Processing Co., Moorestown, N. J.

Dry Flotox wettable sulfur. — Dry Flotox was processed in the micronizer mill, but it was of a formula different from Micronized sulfur. Sold by the California Spray-Chemical Corp., Elizabeth, N. J.

Kolofog wettable sulfur. — Kolofog is a bentonite sulfur product made by fusing sulfur into bentonite. It contains 33 per cent sulfur prepared by the Niagara Chemical Division, Food Machinery & Chemical Corp., Middleport, N. Y.

Fermate. — Fermate is a black, powdered organic fungicide, ferric dimethyl dithiocarbamate. Sold by the E. I. DuPont de Nemours & Co., Inc., Grasselli Chemicals Dept., Wilmington, Del.

Orthex. — Orthex is an emulsified oil type sticker. Prepared by the California Spray-Chemical Corp., Elizabeth, N. J.

S.E.C. oil. — S.E.C. is a self-emulsifying cottonseed oil spreader and sticker. Prepared by the Rohm and Haas Co., Bristol, Pa.

DuPont SS. — DuPont SS is Grasselli or DuPont Spreader-Sticker, which is of a sulfonated alcohol resin type. Manufactured by E. I. DuPont de Nemours & Co., Inc., Grasselli Chemicals Dept., Wilmington, Del.

Casco glue (Grade A). — Casco glue is a casein product prepared by the Casein Company of America, New York, N. Y.

Goulac. — Goulac is lignin pitch. It was sold as Bindarene Flour by the International Paper Company, New York, N. Y.

Sprasoy A. — Sprasoy A is a soybean flour prepared by the Glidden Co., Cleveland, Ohio.

Arsenate of lead. — The Corona brand of lead arsenate without a wetting agent was used. Produced by Corona Chemical Division of the Pittsburgh Plate Glass Co., Milwaukee, Wis.

Lime. — A high-grade hydrated calcium spray lime, 600-mesh, was used in all cases.

PREPARATION OF SPRAYS

The spray materials were placed in a deep box, fitted with a brass wire-mesh screen, over the opening to the tank. Water from the source of supply or from the spray gun was used to wash the materials into the tank with the agitator running. Kolofog was sifted directly into the tank. When hydrated spray lime was used, it was added first or with the fungicide. The arsenate of lead or other insecticide was added last unless some spreader or sticker was used.

TECHNIC OF APPLYING SPRAYS

All sprays were applied by power sprayers equipped with Friend Pecan single nozzle guns at a pressure of 400 to 600 pounds. The trees were thoroughly and evenly covered by one man working from the ground and encircling each tree. Care was taken to avoid "drenching".

Except where otherwise stated, the sprays were applied according to the regular spray schedule with a total of about seven fungicide

applications. (See appendix.) In certain seasons, the early or late sprays were omitted due to dry weather. Most of the applications were made under conditions favorable for drying, before rain periods. As stated in certain experiments, however, the sprays were purposely applied to wet foliage or during light rains to determine the effectiveness under these conditions.

CHOICE OF PLOTS

The experimental orchards were located with the aim of including (a) scab-susceptible varieties, usually McIntosh; (b) uniform trees of good vigor and bearing; and (c) uniform environmental conditions. Plots were located in orchards where the trees were spaced so as to minimize drift. In general, plots of one or two trees were replicated from two to four times, or units of five trees were selected to minimize possible error due to environment or source of primary inoculum.

Experiments were located in orchards with a light primary inoculum and those in which scab had been a major problem the previous year. The relative amount of ascosporic inoculum is indicated in the tables for each orchard.

WEATHER RECORDS

Weather records were kept for each locality in which experiments were conducted, usually directly in the orchard concerned. The amount of rainfall and the length of time the foliage of the trees was wet were recorded to aid in evaluating the retention of the materials and the duration of the infection periods. They are used to interpret the results. The pertinent facts are presented in Table 1 and in the appendix.

EVALUATION OF PRIMARY INOCULUM

Random samples of overwintered leaves from the experimental orchards were examined to determine the abundance of primary inoculum (Tables 2 to 11) and the stage of ascospore maturity (Table 1). The percentage of overwintered leaves bearing perithecia was determined by microscopic examination. When less than 10 per cent of the leaves had perithecia, the carry-over was considered light, between 10 and 30 per cent medium, and over 30 per cent heavy.

METHODS OF TAKING RESULTS

The trees from which the data were taken were selected at harvest as representative in regard to condition, quality of fruit, and location for primary inoculum and other environmental conditions. All of the fruit from these trees was graded unless the amount of scab did not justify the effort. In the instance of a partial count, about 1,000 fruits were taken at random from each tree, but never less than the 250 which are required for the data to be statistically significant.

Fruit was recorded as slightly scabbed if the total scab spots did not exceed ¼ inch in aggregate, such as are included in the U. S. No. 1 grade. All scabby fruit that did not fall in this category was recorded as badly scabbed.

EXPERIMENTAL ORCHARD TESTS

RELATION OF ASCOSPORE DISCHARGE TO HOST DEVELOPMENT AND NUMBER OF INFECTION PERIODS

Records of the earliest and latest probable ascospore discharges in the field for the past 15 years show that in each year spores were mature by the time susceptible host tissue was exposed (Table 1). These records indicate that, regardless of the date of first discharge, enough spores remained until the middle or end of June to cause serious infection if a suitable wetting period developed.

Infection periods occurred in the Hudson Valley in April in about one-half of the years between 1930 and 1944. The host development

TABLE 1.—PERIODS OF ASCOSPORE DISCHARGE, HOST DEVELOPMENT, AND NUMBER OF INFECTION PERIODS, 1930–1944.

YEAR AND LOCATION*	ASCOSPORES MATURE APR. 26†	PERIOD OF ASCOSPORE DISCHARGE‡	MCINTOSH GROWTH AT TIME OF FIRST INFECTION PERIOD	NUMBER OF INFECTION PERIODS PER MONTH§				
				Apr.	May	June	July	Aug.
1930 HV	10	Apr. 20–June 11	Calyx (May 15)	0	2	2	2	0
1931 HV	26	Apr. 21–June 17	Pre-pink (Apr. 23)	1	6	3	2	0
1932 HV	35	May 1–June 17	Delayed dormant (May 1)	0	3	3	0	1
1933 HV	88	Apr. 16–June 19	Delayed dormant (Apr. 16)	2	3	1	1	2
1934 HV	56	Apr. 23–June 19	Pre-pink (May 3)	0	4	2	3	0
1935 HV	25	Apr. 25–June 27	Pre-pink (May 3)	0	3	5	0	0
1936 HV	80	Apr. 3–June 18	Delayed dormant (Apr. 12)	2	2	3	0	0
1937 HV	75	Apr. 14–June 18	Bloom (May 14)	0	4	5	1	2
1937 W	90	Apr. 19–June 29	Delayed dormant (May 5)	0	7	6	0	1
1938 HV	60	Apr. 18–June 14	Pre-pink (Apr. 18)	2	2	3	3	0
1938 W	62	Apr. 12–June 30	Pink (Apr. 29)	1	3	4	1	0
1939 HV	84	Apr. 19–June 12	Calyx (May 23)	0	1	3	0	2
1939 W	90	Apr. 26–July 13	Pink (May 20)	0	3	4	0	0
1940 HV	80	May 1–June 10	Delayed dormant (May 1)	0	4	6	1	0
1940 W	56	Apr. 21–July 1	Green tip (May 2)	0	6	5	2	1
1941 HV	55	Apr. 17–June 15	Pink (Apr. 23)	1	3	5	2	0
1942 HV	45	May 6–June 14	Calyx (May 6)	0	4	5	3	1
1942 W	32	Apr. 18–July 6	Pink (May 2)	0	6	3	2	2
1943 HV	36	Apr. 28–June 15	Delayed dormant (Apr. 30)	0	5	4	2	0
1944 HV	33	Apr. 17–June 23	Green tip (Apr. 24)	1	4	3	1	0

*HV = Hudson Valley; W = Western New York.
†Percentage of perithecia with over 10% of mature spores.
‡Approximate first and last discharge under orchard conditions.
§All wetting periods of 10 hours or more are included for April, May, and June; those of 19 hours or more for July and August.

ranged from the green tip to the pink stage. The first infection period of the season did not occur before petal fall in 1930, 1937, 1939, and 1942. May and June were the months in which infection periods occurred most frequently and host development was most rapid.

It is logical to conclude from the ascospore discharge and host development records that if scab is kept under control to the end of the period of terminal growth, additional applications of a fungicide will not be necessary. The number and timing of sprays to be applied are determined by the rate of growth and the occurrence of wetting periods. A fungicide must be put on between the pink and petal-fall stages of growth if the blooming period is prolonged.

RELATION OF ORCHARD CONDITIONS, CARRY-OVER OF SCAB, AND INFECTION PERIODS TO SPRAY TREATMENTS AND RESULTS

The effectiveness of spray applications for apple scab control may be critically evaluated only when such factors as host development, spray dates, duration of infection periods, and amounts of inoculum and their interactions are carefully correlated as shown in the appendix.

The data accumulated during 1935 to 1944 show the importance of timing the application of the wettable sulfur to keep the new growth protected. Under conditions of abundant inoculum, the elemental sulfur materials failed to protect new growth whenever more than one infection period occurred between sprays. The original sulfur deposit was usually more than sufficient to protect the sprayed tissue for the first infection period and, frequently, through redistribution, protected the new growth. However, if more than one infection period occurred between spray applications, there was not enough sulfur to wash from the sprayed to the new tissue and the latter became infected. It also is a fact that if the rains were heavy or of long duration, the wettable sulfurs as a whole were not sufficiently retentive to give protection to the sprayed parts.

The conditions under which the data were obtained in each of the experimental blocks or kind of test were evaluated as inconclusive, moderate, conclusive, and severe, as follows:

An "inconclusive" test was one in which there were a few short infection periods with light rainfall and where the carry-over of inoculum was small

A "moderate" test was one in which there was an average number of infection periods of short duration, where the timing was

good, and where the carry-over of inoculum was medium to heavy

A "conclusive" test was one in which there were lengthy infection periods, the timing was good and the foliage clean, and the carry-over of inoculum was medium to heavy

A "severe" test was one in which there were lengthy infection periods, the timing was poor and the foliage scabby, and the carry-over of inoculum was medium to heavy

1935 RESULTS

Hudson Valley. — A block of young McIntosh trees (S. E. Mott, Highland) with a light carry-over of scab, representative of a well-sprayed orchard, was used to evaluate the effectiveness of the available fungicides, some at several concentrations. Four applications of the sulfur treatments were made between the pink (May 6) and the second cover spray (June 27) at which time no fungicide was included.

A mature Baldwin block (Gordon Mead, Upper Red Hook) with a heavy carry-over of scab was selected as representative of a scab-resistant variety and one subject to spray injury. The treatments were applied five times between the pink (May 8) and the second cover spray (July 2), inclusive.

The 1935 season was not too favorable for scab development in the Hudson Valley. The ascospores were late in maturing and, although there were eight possible infection periods in the Mott orchard and nine in the Mead block, the timing of the sprays was such as to minimize their importance. The first application in the McIntosh orchard was made in the early pink stage (May 6) just before the first major infection period of 22 hours and 0.8 inch of rain (May 6–7). The treatments were first applied in the Baldwin block May 8, following the infection period. Abundant scab showed up, particularly in the Baldwin block (May 23). Two infection periods of 19 and 30 hours with a total of 1.8 inches of rain occurred the fore part of June between the 10-day and first cover sprays and, no doubt, were responsible for most of the fruit infection.

Records of foliage infection show that, although the second infection period occurred 12 days after the 10-day application, in the McIntosh block with the light carry-over of scab there was little infection, whereas there was considerable in the Baldwin block with the heavy carry-over with an elapsed period of 8 days. Four comparatively short infection periods with a total wetting period of

about 57 hours and 0.9 inch of rain occurred during the period of June 17 to 22, a week after the first cover application, but they caused little infection on the sprayed trees.

The data show the value of keeping scab under control (Table 2, Ser. 1 and 2). Severe scab infection did not develop in the McIntosh orchard with little primary inoculum. The unsprayed trees developed only 50 per cent scabby fruit (Ser. 1). The unsprayed Baldwins, a scab-resistant variety, were completely scabbed due to heavy spore discharges during the early season (Ser. 2).

The results of these experiments show that the lime sulfur-containing materials and wettable sulfurs, wet or dry, fine or coarse, are quite effective against scab at low concentrations when applied under conditions where the test is not too critical. Counts from the

Table 2.—Effectiveness of Paste and Dry Wettable Sulfurs and Liquid and Dry Lime-Sulfur Applied Under Conditions Unfavorable for a Conclusive Test, 1935.

Treatment*	Percentage scabbed fruits		
	Slight	Bad	Total
Ser. 1—McIntosh (S. E. Mott, Highland) Inoculum Light, Inconclusive Test†			
Untreated	19	32	51
Lime-sulfur 1–100	1	0	1
Dry lime-sulfur 3–10–100	3	3	6
Dry lime-sulfur 5–10–100	3	2	5
Magnetic-Spray 4–100	2	0	2
Mulsoid 6–100	2	1	3
Sulcoloid 6–100	3	1	4
Koppers Dry 3–100	1	0	1
Koppers paste 6–100	2	1	3
Camden paste 6–100	1	0	1
Kolofog 6–100	5	4	9
Lime 10–100	9	10	19
Ser. 2—Baldwin (Gordon Mead, Upper Red Hook) Inoculum Heavy, Moderate Test‡			
Untreated	8	91	99
Lime-sulfur 1–100	1	0	1
Lime-sulfur 2–100	0	0	0
Dry lime-sulfur 6–10–100	1	0	1
Sulcoloid 6–100	2	0	2
Koppers Dry 5–100	0	0	0
Lime 10–100	14	3	17

*Lime 3–100 and goulac ½–100 were added to the lime-sulfur before the arsenate of lead. No lead was used in either block in the petal fall spray. Lead and lime 3–3–100 were used in the three following applications.

†The Koppers Dry and Camden paste were applied May 3 before two questionable infection periods and the remainder of the treatment May 6. No fungicide in the second cover June 27.

‡Lime-sulfur 2–100 and lime 10–100 were applied to their respective plots in the delayed dormant April 27 and the remainder of the plots received the Koppers Dry Wettable.

trees sprayed with Kolofog indicated that it was an inferior material. Lime 10–100 proved to have fungicidal properties.

1936 RESULTS

Hudson Valley. — A block of medium-sized McIntosh trees (E. Rodrequez, Wappingers Falls) with a heavy carry-over of scab was used. Four applications of the treatments were made between a late delayed dormant or pre-pink (April 25) and the 10-day spray (May 19), inclusive.

The season was a week earlier than that of 1935. Ascospores also matured early and abundant spores were ready to be discharged April 3, the earliest date for ascospore maturity in the Hudson Valley recorded during the period of 1930 to 1944.

Although there were over 20 wetting periods, there were only 7 that could be considered possible infection periods. The first infection period occurred during a wetting period of 38 hours with 0.4 inch of rain at the early delayed dormant stage (April 12). Lime-sulfur 1½–100 was applied the following day. Scab was first observed May 5 on the cluster leaves. No serious infection period occurred until May 18, the day before the 10-day spray was applied when the trees were wet for 29 hours with a rainfall of 1.5 inches. (See appendix.) The Kolofog, lime, and dry mix plots were sprayed May 19 and the remainder of the treatments were put on May 21. Scab resulting from this rain was observed June 3. A prolonged wetting period of 35 hours with 1.9 inches of rain occurred on June 14, but very few ascospores were left to be discharged at that time. There was some infection on the terminal leaves. Lime 10–100 was applied as the fungicide to the entire block in the first cover and Sulcoloid 6–100 was included in the second cover (July 9), except on the lime plots.

In general, the season of 1936 was not as favorable for scab development as that of 1935. Applications of even the weaker sulfur fungicides at very low concentrations afforded adequate protection (Table 3). Lime 10–100 was quite effective, as in 1935. The unsprayed trees developed only 62 per cent fruit infection, and all of the fungicide treatments held scab to less than 2 per cent.

The results obtained show the importance of testing the same fungicides over a period of years in order to determine their true effectiveness. Such materials as dry mix, Mulsoid, Sulcoloid, Kolofog, and Magnetic-Spray, which under the conditions of this experiment

TABLE 3.—EFFECTIVENESS OF PASTE AND DRY WETTABLE SULFURS AT LOW CONCENTRATIONS APPLIED IN A SEASON UNFAVORABLE FOR APPLE SCAB DEVELOPMENT, 1936.

TREATMENT*	PERCENTAGE SCABBED FRUITS		
	Slight	Bad	Total
McIntosh (E. Rodrequez, Wappingers Falls)—Inoculum Heavy			Inconclusive Test
Untreated	18	44	62
Lime-sulfur 1–100	1	0	1
Koppers Paste 5–100	1	0	1
Camden paste 4–100	0	0	1
Dry mix 6–3–100	1	1	2
Mulsoid 6–100	1	0	1
Sulcoloid 6–100	1	1	2
Kolofog 6–100	0	1	1
Magnetic-Spray 2–100	1	0	1
Mike 2–100	0	0	1
Lime 10–100	5	5	10

*Lime 3–100 and goulac ½–100 were added to the lime-sulfur before the arsenate of lead. Blood albumen ½–100 was used as the wetting agent for the 325-mesh elemental sulfur and the lime in the dry mix and the lime applied alone. Lime-sulfur 1½–100 was applied to the entire block in the early delayed dormant. Arsenate of lead 2–100 was included in the early and late delayed dormant, the 10-day, and first cover sprays. Calcium arsenate 3-100 was used in the 2nd cover spray. Lime 10–100 with no fungicide was applied to all the plots in the first cover. Sulcoloid 6–100 was included with the calcium arsenate and lime, except on the lime block in the second cover. In the 10-day spray, the Kolofog, lime, and the dry mix plots were sprayed May 19 and the remainder of the plots May 21.

gave perfect control, did not adequately control scab in subsequent tests (1937 to 1938) when conditions were more favorable for scab development.

1937 RESULTS

Western New York. — Three McIntosh orchards for fungicide testing were located with Charles Wilson, Hall; George Mead, Barker; and Paul Mattar, Youngstown. The source of primary inoculum in the Wilson and Mattar orchards was quite abundant, while that in the Mead orchard was light. Seven applications of the treatments were made in the Wilson and Mattar blocks, beginning with the delayed dormant and pre-pink sprays, respectively, and eight in the Mead orchard, beginning with the delayed dormant.

Weather conditions were such that practically all the fruit was scabbed on unsprayed trees in all three locations. Numerous and prolonged wetting periods, together with a long pre-bloom period and a good growing season, made for a severe test for sulfur fungicides. Out of some six or seven possible infection periods during May, there were two rain periods, May 13 to 14 and May 16 to 17, at the time of the pre-pink and pink sprays that caused appreciable scab. Heavy infection was observed on the cluster leaves on the check trees (May 27 to 29). There were four infection periods in

mid-June, two preceding the first cover spray and two immediately after, that caused some increase in secondary scab on trees sprayed with the weaker treatments. The last infection period occurred June 27 to 28. A comparatively dry summer followed. The data obtained were not the results of near-perfect timing of sprays but were an indication of their effectiveness in holding scab already established.

The foliage in the Wilson orchard was heavily scabbed. Liquid lime-sulfur 1–75 prevented fruit infection, while the wettable sulfurs, Micronized 4–100, Camden paste 8–100, and dry mix 6–3–100, allowed 3, 4, and 6 per cent fruit infection, repectively (Table 4, Ser. 1).

Table 4.—Evaluation of Paste and Dry Wettable Sulfurs as Determined by Concentration and Particle Size, 1937.

Treatment*	Percentage scabbed fruits		
	Slight	Bad	Total
Ser. 1—McIntosh (Charles Wilson, Hall)—Inoculum Fairly Heavy—Conclusive Test†			
Untreated	0	100	100
Lime-sulfur 1½–100	0	0	0
Camden paste 8–100	2	2	4
Micronized 4–100	2	1	3
Dry mix 6–3–100	4	2	6
Ser. 2—McIntosh (George Mead, Barker)—Inoculum Light—Inconclusive Test‡			
Untreated	7	89	96
Lime-sulfur 1–100	0	0	0
Magnetic-Spray 3–100	5	2	7
Magnetic-Spray 6–100	1	0	1
Camden paste 6–100	5	3	8
Ser. 3—McIntosh (Paul Mattar, Youngstown)—Inoculum Heavy—Moderate Test§			
Untreated	0	100	100
Lime-sulfur 1–100	2	1	3
Lime-sulfur 1½–100	1	1	2
Lime-sulfur 2–100	1	1	2
Koppers paste 6–100	5	1	6
Koppers paste 10–100	2	1	3
Dry mix 3–3–100	24	30	54
Dry mix 6–3–100	8	5	13

*Lime 3–100 and goulac ½–100 were added to the lime-sulfur before the arsenate of lead. Blood albumen ½–100 was used as the wetter in the dry mix.

†Arsenate of lead 3–100 was used in the delayed dormant, petal fall, and 2 cover sprays.

‡Arsenate of lead and lime 4–4–100 were added in 4 cover sprays.

§Calcium arsenate and lime 4–4–100 were used in the pre-pink, arsenate of lead and lime 3–3–100 in the petal fall, and lead and lime 4–4–100 in 4 cover sprays. Lime-sulfur 1½–100 and dry mix 6–3–100 were applied in the delayed dormant, but the rest of the plots received Koppers paste 10–100.

TABLE 4.—CONCLUDED.

TREATMENT*	PERCENTAGE SCABBED FRUITS		
	Slight	Bad	Total
Ser. 4—McIntosh (Harold Wilson, Clermont)—Inoculum Medium -Severe Test¶			
Untreated	2	98	100
Lime-sulfur 1½–100	2	1	3
Camden paste 4–100	15	15	30
Camden paste 8–100	4	4	8
Camden Dry 8–100	9	13	22
Mike 2–100	15	14	29
Mike 4–100	10	11	21
Magnetic-Spray 2–100	19	33	52
Magnetic-Spray 4–100	14	13	27
Magnetic-Spray 6–100	9	11	20
Sulcoloid 4–100	23	25	48
Lime 3–100	11	82	93
Ser. 5a—Cortland (O. C. Pinckney, Fishkill)—Inocolum Heavy—Severe Test‖			
Untreated	0	100	100
Lime-sulfur 1½–100	8	14	22
Koppers Paste 8–100	10	29	39
3.7 micron 4–100	10	9	19
6.6 micron 4–100	13	18	31
10.3 micron 4–100	14	50	64
Ser. 5b—Delicious (O. C. Pinckney, Fishkill)—Inoculum Heavy—Severe Test‖			
Untreated	0	100	100
Koppers paste 8–100	5	10	15
3.7 micron 4–100	4	6	10
6.6 micron 4–100	8	12	20
10.3 micron 4–100	18	32	50

*Lime 3–100 and goulac ½–100 were added to the lime-sulfur before the arsenate of lead. Blood albumen ½–100 was used as the wetter in the dry mix.

¶Lead arsenate and lime 3–3–100 were added in all the sprays from the pink through the 3rd cover, calcium arsenate and lime 3–6–100 in the 4th cover, and 2–4–100 in the 5th cover.

‖Same as Ser. 4, except calcium arsenate was omitted in the 6th cover. The particle size of the sulfurs is the surface average diameter.

Control of apple scab in the Mead orchard was obtained with lime-sulfur 1–100 and Magnetic-Spray 6–100 (Table 4, Ser. 2). The plots treated with Magnetic-Spray 3–100 and Camden paste 6–100 had 7 and 8 per cent scab, respectively. Judging by the scab on the check trees, the test was more critical for the Camden paste.

In the Mattar orchard, there was no significant difference in scab control between plots receiving 1.0, 1.5, and 2.0 gallons of lime-sulfur (Table 4, Ser. 3). Koppers paste 10–100 was equally as effective as lime-sulfur 1–100, with 3 per cent scab. The Koppers paste 6–100 contained enough sulfur to give commercial control of scab. Dry mix failed to hold scab; at 6–3–100, 13 per cent scab developed and at 3–3–100, 54 per cent of the fruit was infected.

Hudson Valley.—Plots with abundant primary inoculum were

located in the McIntosh block of Harold Wilson, Clermont, and in the mixed planting of Cortland and Delicious in the Pinckney orchard, Fishkill. Eight applications of the treatments were made in the Wilson block and nine in the Pinckney orchard, beginning with the delayed dormant spray. There were two applications before bloom.

Environmental conditions were favorable for scab development in 1937. There were 10 possible infection periods in the Wilson block and 12 in the Pinckney orchard. The first infection period occurred during the long bloom period about a week after the pink spray was applied. (See appendix.) New foliage growth and the young fruits were infected at this time and served as a source of secondary inoculum for the rest of the season. Another important infection took place in the Pinckney planting a week following the petal-fall spray. Special scab sprays were applied in early June to the plots in both blocks to check the development of scab on the rapidly growing fruit. Several long, wet periods occurred during June and secondary scab continued to develop in all of the plots sprayed with the weaker treatments. Further prolonged infection periods during July and August furnished ideal conditions for secondary pin-point scab, especially in the Wilson block. Late infection was showing at harvest time.

The tests were designed to determine the effect of the particle size of the various wettable sulfur materials on scab control. The fruit on the unsprayed trees in both blocks was 100 per cent scabbed (Table 4, Ser. 4, 5a, and 5b). In the Wilson block, lime-sulfur 1½–100 gave the best control with 3 per cent scab (Ser. 4). The plot of Camden paste 8–100 had 8 per cent scab as against 22 per cent for the dry form at the same sulfur concentration. The fruit of the trees sprayed with Mike (5.3μ), Magnetic-Spray (8.3μ), and Sulcoloid (14.2μ), each at 4–100, developed 21, 27, and 48 per cent scab, respectively, showing that scab control decreased as the average size of the sulfur particles increased.

In the Pinckney block micronized sulfurs of 3.6, 6.6, and 10.3 microns were tested at 4–100 in comparison with approximately equivalent sulfur concentrations of lime-sulfur and flotation paste (Fig. 1). The 3.6-micron sulfur was equally as effective as the lime-sulfur and definitely superior to the Koppers paste (Table 4, Ser. 5a and 5b). The 3.6-, 6.6-, and 10.3-micron sulfur allowed 19, 31, and 64 per cent scab, respectively, on Cortland and 10, 20, and 50 per cent,

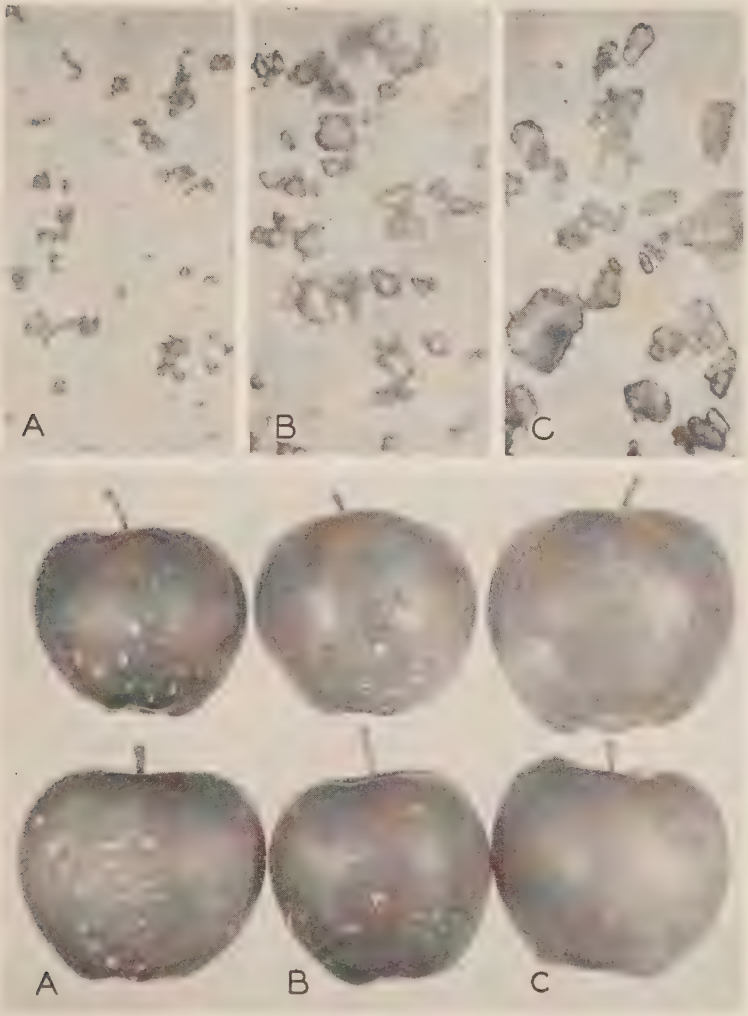

FIG. 1.—RELATION OF PARTICLE SIZE TO ADHERENCE OF SULFUR FUNGICIDES. *Top* row, sulfur samples with average particle sizes of 3.6 microns (A), 6.6 microns (B), and 10.3 microns (C), taken from materials used in the orchard tests. *Bottom row,* Delicious apples sprayed with 3.6-, 6.6-, and 10.3-micron sulfurs, respectively. Fruit photographed after 6.5 inches of rain.

respectively, on Delicious. These data corroborate the findings in the Wilson block which indicated that particle size was a predominating factor in the performance of a dry wettable sulfur.

The difference in degree of apple scab control in 1937 as compared with that of 1935 or 1936 is a good illustration of the necessity for testing fungicides in the field over a period of years. Materials such as Sulcoloid, which gave adequate control under conditions not too favorable for scab development, allowed 48 per cent scab in 1937 with more favorable scab weather.

1938 RESULTS

Western New York. — The 1937 McIntosh block of Paul Mattar, Youngstown, was used. For all practical purposes, ascosporic inoculum was limited to the check trees of the previous season which were located with two-tree intervals in every other row. Nine applications of the materials were made, beginning with the pre-pink spray. Although there were over 30 rain periods, there were only 9 of 10 to 16 hours' duration before the end of June; that is, there were no major infection periods. Scab was first observed May 26. At harvest, 55 per cent of the fruit from the unsprayed trees would have passed U. S. No. 1 grade so far as scab was concerned. There were no significant differences between the materials tested (Table 5, Ser. 1). Koppers paste 5–100 and the dry wettables, Flotox and Mike, each 5–100, gave complete scab control. Similar data not recorded here were obtained in another McIntosh block (Earl Harding, Albion). In this orchard Koppers paste, Stauffer's Magnetic "70" paste, Camden paste, Mike and Flotox, each 5–100, were completely effective.

Hudson Valley. — There were two McIntosh orchards, one having 1 per cent of the old leaves with perithecia (Albert Tabor, Milton) and the other with 38 per cent (Astor Estate, Rhinebeck). The two types of orchards were used for fungicide tests to determine what changes in spray concentrations or schedules might be made for like situations.

The season was early and the delayed dormant spray was omitted. Five applications were made in the Tabor orchard and seven at the Astor Estate. There were 9 possible infection periods, 6 of which occurred before the end of June. All plots in the Astor Estate block received lime-sulfur 2–100 in the pre-pink application (April 19), following a 22-hour infection period. (See appendix.) A 20-hour

TABLE 5.—EFFECTIVENESS OF PASTE AND DRY WETTABLE SULFURS AS DETERMINED BY WETTING PERIODS, CARRY-OVER OF INOCULUM, CONCENTRATION, AND PARTICLE SIZE, 1938.

TREATMENT	PERCENTAGE SCABBED FRUITS		
	Slight	Bad	Total
Ser. 1—McIntosh (Paul Mattar, Youngstown)—Inoculum Medium—Inconclusive Test*			
Untreated	30	45	75
Koppers paste 5–100	1	0	1
Koppers paste 8–100	1	0	1
Koppers paste 5–100, Orthex 1 pt	0	0	0
Dry Flotox 5–100	0	0	0
Dry Flotox 3–100, Orthex 1 pt	0	0	0
Mike 5–100	0	0	0
Ser. 2—McIntosh (Albert Tabor, Milton)—Inoculum Light—Inconclusive Test†			
Untreated	21	36	57
Lime-sulfur 1½–100	0	0	0
Koppers paste 4–100	0	1	1
Koppers paste 8–100	0	1	1
Micronized 4–100	0	1	1
Mike 4–100	0	1	1
Ser. 3—McIntosh (Astor Estate, Rhinebeck)—Inoculum Heavy—Conclusive Test†			
Untreated	6	94	100
Lime-sulfur 1½–100	2	3	5
Magnetic "70" paste 8–100	1	1	2
Camden paste 10–100	1	2	3
Koppers paste 10–100	1	1	2
Hudson Valley paste 10–100	1	1	2
Magnetic "70" paste 4–100	2	3	5
Camden paste 6–100	3	7	10
Koppers paste 6–100	2	6	8
Hudson Valley paste 6–100	2	3	5
Micronized 5–100	2	5	7
Mike 5–100	1	3	4
Magnetic-Spray 6–100	3	7	10
Sulcoloid 6–100	3	9	12
3.7 micron 5–100	2	3	5
6.6 micron 5–100	3	5	8
10.3 micron 5–100	8	10	18
3.7 micron 3–100	4	7	11
6.6 micron 3–100	5	7	12
10.3 micron 3–100	5	19	24

*Arsenate of lead 4–100 was added in the petal fall and 1st cover, 3–100 in the 2nd cover, and 2–100 in the 3rd cover. Fixed nicotine was used in the 4th and 5th covers.

†Arsenate of lead 3–100 was added throughout. The particle size of the sulfurs is the surface average diameter.

wetting period occurred during bloom, about 5 days after the pink application. Unprotected growth was infected. Two infection periods of 22 and 16 hours occurred during May. At the Astor Estate where there was a considerable carry-over of scab, one period came just after the 10-day application and the other just before the

1st cover spray, so all the better materials were effective. Several rains in June resulted in two infection periods of over 40 hours each and much of the sulfur was removed from the leaves and fruit of plots sprayed with the coarser materials. A total of 7½ inches of rain fell during June. A 2-day rain and two shorter infection periods occurred in July with a total of over 6 inches of rain. Secondary scab was showing up on the plots with the weak treatments at harvest time.

In the Tabor orchard with the light primary inoculum, the unsprayed trees developed 57 per cent scabby fruit compared to 100 per cent infection in the Astor block under conditions of a heavy primary inoculum (Table 5, Ser. 2 and 3). Five applications of the wettable sulfurs at low concentrations gave better scab control than seven applications at higher concentrations in the two blocks, respectively.

The several sulfur pastes applied at a concentration containing 2 to 3 pounds of actual sulfur gave commercial control of scab, but the group as a whole was more effective at a dosage that contained at least 4 pounds of sulfur (Table 5, Ser. 3). The 3.7-micron sulfur and the Micronized and Mike sulfurs of comparable average particle size were effective at 5–100. The 6.6- and 10.3-micron sulfurs, each 5–100, and the Magnetic-Spray and Sulcoloid, each 6–100, of comparable particle size to the 6.6- and 10.3-micron sulfurs, respectively, were proportionately less protective, substantiating the fact that control is improved as the particle size is reduced. These data corroborate the results obtained in 1937.

1939 RESULTS

Western New York. — A McIntosh block (R. Brandt, Point Breeze) with a heavy carry-over of scab and as much isolation as possible was selected to evaluate the effect of ground spraying on the scab control obtained with several fungicides. Seven applications of fungicide were made, six of which included all the materials to be tested.

The season was not favorable for scab development. Although there were 18 wetting periods during May, June, and July, the rainfall was almost 4 inches below average. The dry weather was such that the ascospores were discharged with showers in mid-July and there was no late development of scab. The first infection period occurred 2 days before the pink spray, which was the first spray applied. The cluster leaves were heavily scabbed June 5. An im-

portant infection period occurred June 13, 10 days after the petal-fall spray. Most of the fruit scab was on the pedicels and the calyx end. There were two infection periods following the application of the 2nd and 4th cover sprays.

The ground application of Elgetol did not reduce appreciably the scab inoculum potential. There was between 25 and 32 per cent scab on the fruit from the plots sprayed with Stauffer's Magnetic "70" paste, Koppers paste, Flotox, and Mike sulfur, whereas there was only 11 per cent on the lime-sulfur trees (Table 6, Ser. 1). The assumption is that the data are not a test of retention but of eradicative action.

Hudson Valley. – The test of fungicides was conducted in a McIntosh orchard (M. Shultis, Modena) with a heavy carry-over of inoculum. There were eight applications of the materials, beginning with the pre-pink spray. The weather conditions were not favorable

Table 6.—Evaluation of Paste and Dry Wettable Sulfurs as Determined by Concentration and Particle Size, 1939.

Treatment	Percentage scabbed fruits		
	Slight	Bad	Total
Ser. 1—McIntosh (R. Brandt, Point Breeze)—Inoculum Heavy—Severe Test*			
Untreated	34	39	73
Lime-sulfur 1–75	6	5	11
Magnetic "70" paste 5–100	14	13	27
Koppers paste 8–100	11	15	26
Flotox 5–100	17	15	32
Mike 5–100	13	12	25
Ser. 2—McIntosh (M. Shultis, Modena)—Inoculum Heavy—Inconclusive Test†			
Untreated	12	80	92
Lime-sulfur 1½–3–100	3	1	4
Koppers paste 6–100	1	0	1
Koppers paste 8–100	0	0	0
Koppers paste 10–100	0	0	0
Koppers paste 5–100, Orthex 1 pt	0	0	0
Dry Flotox 3–100, Orthex 1 pt	4	2	6
Magnetic "70" paste 3–100	0	0	0
Magnetic "70" paste 6–100	0	0	0
Micronized 5–100	0	0	0
Mike 5–100	1	0	1
3.7 micron 4–100	T‡	T	1
6.6 micron 4–100	2	T	3
10.3 micron 4–100	15	20	35
10.3 micron 8–100	12	10	22

*Lime-sulfur 1–100 with Micronized 3–100 was applied to the whole block May 23. The ground of the block was sprayed with Elgetol before growth began. Arsenate of lead was included in the petal fall and 5 cover sprays.

†Arsenate of lead and lime 3–3–100 were added throughout. The particle size of the sulfurs is the average surface diameter.

‡T = Less than 0.5 per cent scab.

for severe scab development. There were two 20-hour primary infection periods — one in May and one in June. There were two 20-hour secondary infection periods in mid-August which allowed some pin-point infections to appear on fruit in plots sprayed with coarse sulfur.

Unsprayed trees averaged 92 per cent scabby fruit at harvest (Table 6, Ser. 2). Koppers paste 6–100, Magnetic "70" paste 3–100, Micronized sulfur 5–100, Mike 5–100, and lime-sulfur 1½–100 gave almost complete control. The 3.6- and 6.6-micron materials 4–100 gave results comparable to the above commercial wettable sulfurs. The sulfur of 10.3-micron average particle size was definitely inferior to that of 3.6 and 6.6 microns. The particle size was not fully compensated for by an increase in concentration. The plots sprayed with 10.3-micron sulfur at 4–100 had 35 per cent scab, whereas those sprayed with 10.3-micron 8–100 had 22 per cent. The season was not suitable for the evaluation of stickers.

1940 RESULTS

Western New York. — The McIntosh block (Paul Mattar, Youngstown) in which the experiments were conducted in 1937 and 1938 was used. There was a considerable carry-over of scab. Eight applications of the treatments were made between the delayed dormant and fourth cover.

The ascosporic inoculum was mature and ready to be discharged before any host tissue was exposed (Table 1). The first infection period occurred when the trees were in the green-tip stage (May 2), but little infection took place. Both the delayed dormant and pre-pink sprays were followed by two infection periods each of from 12 to 15 hours. (See appendix.) Scab from these mid-May rains began to appear the first part of June at petal fall. Three wet periods during bloom were of sufficient length for infection to occur. Both the petal fall and first cover sprays were followed by two infection periods of from 13 to 18 hours. Two 20-hour infection periods occurred in early July which made the set-up for considerable secondary infection on plots with weak treatments. This was a good season in which to test fungicides and the most effective materials could be readily identified. All of the fruit on unsprayed trees was scabby and foliage burned up with scab by July.

The Koppers paste 10–100, Magnetic "70" paste 6–100, and lime-sulfur 1½–100 plots had 5 per cent or less scabbed fruit (Table 7,

Ser. 1). Koppers paste 6–100 gave control inferior to Camden paste 6–100 and Magnetic "70" paste 4–100, the plots having 17, 11, and 10 per cent scab, respectively. Micronized sulfur 5–100 allowed 7 per cent scab as against 16 per cent for the Stauffer's Dry and Mike, each 5–100. The data obtained from the addition of spreader-stickers indicate that they were not justified so far as reduction in concentration of sulfur was concerned. Good distribution of material ap-

TABLE 7.—PERFORMANCE OF PASTE AND DRY WETTABLE SULFURS, WITH AND WITHOUT SPREADER-STICKERS, 1940.

Treatment*	PERCENTAGE SCABBED FRUITS		
	Slight	Bad	Total
Ser. 1.—McIntosh (Paul Mattar, Youngstown)—Inoculum Heavy—Conclusive Test*			
Untreated	0	100	100
Lime-sulfur 1½–3–100	2	2	4
Camden paste 6–100	7	4	11
Koppers paste 6–100	8	9	17
Koppers paste 10–100	2	3	5
Koppers paste 5–100, Orthex 1 pt	6	5	11
Magnetic "70" paste 4–100	5	5	10
Magnetic "70" paste 6–100	1	3	4
Stauffer's Dry 5–100	6	10	16
Mike 5–100	8	8	16
Micronized 5–100	4	3	7
Micronized 3–100, Orthex 1 pt	15	5	20
Micronized 3–100, S.E.C. ½ pt	4	5	9
Micronized 3–100, DuPont SS 1½ oz	7	4	11
Kolofog 6–100	18	38	56
Ser. 2.—McIntosh (Irving Fraleigh, Red Hook)—Inoculum Heavy—Moderate Test†			
Untreated	3	95	98
Lime-sulfur 1½–3–100	1	3	4
Hudson Valley paste 6–100	T‡	T	1
Hudson Valley paste 6–100, Orthex 1 pt	0	1	1
Hudson Valley paste 10–100	T	T	1
Camden paste 6–100	1	2	3
Camden paste 10–100	0	1	1
Magnetic "70" paste 4–100	0	1	1
Magnetic "70" paste 6–100	0	1	1
Stauffer's Dry 5–100	1	8	9
Mike 5–100	2	6	8
Micronized 5–100	1	1	2
Micronized 3–100, Orthex 1 pt	1	3	4
Micronized 3–100, S.E.C. ½ pt	3	6	9
Micronized 3–100, DuPont SS 1½ oz	2	4	6
Kolospray 6–100	2	5	7

*Arsenate of lead 3–100 was added in the pre-pink, petal fall, and 4 covers.

†Hudson Valley paste alone and with Orthex was applied during a 32-hour infection period before the pink spray, after which there was an inch of rain before drying. The remainder of the treatments was applied the following day. Arsenate of lead 3–100 was added from calyx through 1st cover and calcium arsenate 3–3–100 in the 2nd and 3rd covers.

‡T = Less than 0.5 per cent scab.

peared to be as important a factor as residue building. Orthex was added to permit spraying under poor drying conditions, a factor that would not be apparent in these tests. It caused injury in the midseason cover sprays. Flotation sulfur seemed to work better with Orthex than Micronized. Later, it was found necessary to add lime 1–100 to the spray when Orthex was used to prevent the Orthex inhibiting the fungicidal action of the sulfur. This probably accounts for the high percentage of scab in this block. S.E.C. oil did not cause injury to the foliage as did Orthex.

Mike sulfur and Stauffer's Dry, which are made by the same process, gave identical control and both were inferior to Micronized. It was further evident from a comparison of Stauffer's Dry and paste that the wet type was more effective. While the wet types are, in general, more effective than the dry types, effectiveness depends upon the adjuvants and the particle size. The plots sprayed with Kolofog 6–100 had 55 per cent of the fruit scabbed. The plots sprayed with Kolofog had a heavy drop of fruit before harvest.

Hudson Valley. — A McIntosh block of low vigor belonging to Irving Fraleigh, Red Hook, was used. The trees were of average size, low in vigor, and had a light crop due to poor pollination. The scab carry-over was heavy and the spores were ready to discharge at the time of the delayed dormant (May 1). Seven applications of the materials were made, beginning with the pre-pink (May 8). A 32-hour infection period occurred May 16 and was followed by the pink application the next day. Three infection periods of 21, 30, and 50 hours occurred during bloom and started considerable infection in the trees receiving the weaker treatments. Three long infection periods occurred in June, one of 34 hours after the petal-fall spray and two of over 30 hours following the first cover application. Secondary scab developed on the trees sprayed with the poor materials at the time of a 40-hour infection period in mid-July. The season was generally favorable for scab development. The unsprayed trees were almost completely scabby by harvest.

The plots sprayed with Hudson Valley and Camden pastes 6–100, Magnetic "70" paste 4–100, Micronized sulfur 5–100, and lime-sulfur 1½–100 had 4 per cent or less scabbed fruit (Table 7, Ser. 2). Mike and Stauffer's Dry, each 5–100, with 8 and 9 per cent scab, respectively, were inferior, as they were in the Youngstown plots. Also, the wet type, Magnetic "70," was again superior to the dry

type, Stauffer's Dry. Kolospray 6–100 gave about the same protection as Mike and Stauffer's Dry.

The results obtained from the addition of the spreader-stickers Orthex, S.E.C. oil, and DuPont SS to Micronized sulfur 3–100 had the same trend as at Youngstown. The application of the Hudson Valley paste 6–100 and 10–100 alone and the Hudson Valley paste 6–100 with Orthex during the 1-inch rain at the time of the pink application failed to bring out any advantage from the use of Orthex. The Hudson Valley paste alone gave complete control.

While the trend of control with the various treatments corresponded with that of the Youngstown block, it is pertinent to note the contrast in degree of effectiveness.

1941 RESULTS

Hudson Valley. — Fungicidal tests were conducted in two McIntosh blocks (C. Ligatino, Ohioville, and Dr. Lasher, Germantown) with abundant inoculum. The trees were of medium size and well spaced for experimental plots. The crop at Ohioville was very light, due to a frost during early bloom.

Ascospores were mature at the time of the delayed dormant. Five applications of the fungicides were made, beginning with the pink spray (April 24). There were five possible infection periods in the Ligatino orchard and eleven at Lasher's. The first infection period occurred 1 week after the petal-fall spray in the Ligatino orchard and at the pink stage in the Lasher block. Little infection occurred in either orchard, except on the unsprayed trees. There were no infection periods during bloom.

In the Ligatino block, there was a 24-hour wetting period one week after the petal-fall spray. There was an infection period of 36 hours the day before the first cover spray was applied. There were three substantial wetting periods in June, the last one of 24 hours' duration with 2 inches of rain preceding the second cover spray, June 19. There was a total rainfall of 2.6, 7.5, and 5.3 for the months of May, June, and July, respectively.

In the Lasher block, there was an infection period of 28 hours following the petal-fall spray. There were three possible infection periods between the 10-day and first cover applications, one of which was 26 hours preceding the first cover spray. There was a wetting period of 46 hours with 1.7 inches of rain just after the first cover and one of 50 hours with 1.6 inches of rain 10 days later. There were

two other possible primary infection periods in June and two secondary infection periods in July. Secondary scab developed on the fruit before harvest in those plots that had foliage infection early in the season.

Practically all of the fruit on the unsprayed trees were scabbed by harvest (Table 8, Ser. 1 and 2). In the Ligatino orchard, Hudson Valley paste 8–100, Magnetic "70" 6–100, Fungisul 4–100, Koppers Dry 5–100, Micronized 5–100, Sulforon 5–100 with Orthex, and Fermate 2–100 gave complete control (Table 8, Ser. 1). The Magnetic "70" paste 4–100, Fungisul 2–100, and Koppers Dry 3–100 plots had 6, 36, and 27 per cent scab, respectively. It is indicated that the concentrations of the latter two materials were too low to have sufficient sulfur for redistribution. Trees sprayed with Sulforon 5–100, Mike 5–100, and Kolofog 6–100 had 10, 11, and 9 per cent scab, respectively. The effectiveness of Sulforon, a comparatively coarse sulfur, was definitely increased with the addition of Orthex.

Similar treatments in the Lasher orchard were effective irrespective of type, concentration, particle size, or addition of lime and spreader-stickers (Table 8, Ser. 2).

1942 RESULTS

Western New York. — Tests were conducted in a McIntosh orchard (F. S. McMichael, Geneva) with a heavy carry-over of primary inoculum. Six applications of the materials were made. The first spray, the pre-pink application, was made April 29. The first infection period occurred in the pink (May 2) and scab showed up May 17. Infection periods that initiated considerable primary scab took place about 1 week after each of the pre-pink, late bloom, special scab, and first cover applications. The petal-fall spray probably gave protection for the three almost continuous infection periods that occurred following its application. Scab was abundant on the foliage by mid-June. Numerous wetting periods during July and August with considerable rainfall thoroughly tested the retention of the materials. (See appendix.)

The plots sprayed with a mixture of Micronized sulfur 3–100 and Fermate ½–100 had 2 per cent scab (Table 9, Ser. 1), while the Micronized sulfur 5–100 and Fermate 1½–100 treatments had 4 and 6 per cent scab, respectively, indicating that the materials were more effective when used together than when used alone. Fermate ¾–100 did not keep scab under control. The addition of Orthex to Micro-

TABLE 8.—EVALUATION OF PASTE AND DRY WETTABLE SULFURS WITH CONSIDERATION FOR CONCENTRATION AND SPREADER-STICKERS, 1941.

TREATMENT	PERCENTAGE SCABBED FRUITS		
	Slight	Bad	Total
Ser. 1—McIntosh (C. Ligatino, Ohioville)—Inoculum Heavy—Moderate Test*			
Untreated	0	100	100
Hudson Valley paste 8–100	0	1	1
Magnetic "70" paste 4–100	3	3	6
Magnetic "70" paste 6–100	1	1	2
Fungisul 2–100, Casco glue ¼ lb	20	16	36
Fungisul 4–100, Casco glue ¼ lb	1	1	2
Koppers Dry 3–3–100	14	13	27
Koppers Dry 5–100	T†	T	1
Mike 5–3–100	4	7	11
Micronized 5–100	1	1	2
Micronized 5–100, S.E.C. ½ pt	1	0	1
Sulforon 5–100	3	7	10
Sulforon 5–100, Orthex 1 pt	1	0	1
Kolofog 6–100	4	5	9
Fermate 2–1–100	0	0	0
Ser. 2—McIntosh (Dr. Lasher, Germantown)—Inoculum Medium—Inconclusive Test*			
Untreated	11	86	97
Lime-sulfur 1½ 100	0	0	0
Hudson Valley paste 6–100	0	0	0
Koppers paste 6–100	0	0	0
Magnetic "70" paste 4–100	T	T	1
Magnetic "70" paste 6–100	0	0	0
Sulforon 5–100	1	0	1
Mike 5–100	0	1	1
Mike, lime 5–3–100	T	T	1
Kolospray 6–100	1	0	1
Kolofog 6–100	0	0	0
Koppers Dry 3–3–100	0	0	0
Koppers Dry 5–3–100	0	0	0
Micronized 3–3–100	T	T	1
Micronized 5–3–100	0	0	0
Micronized 3–100, Orthex 1 pt	1	1	2
Micronized 3–100, S.E.C. ½ pt	1	1	2
Micronized 3–100, DuPont SS 1½ oz	0	0	0
Micronized 3 + Fermate 1–100	0	0	0

*Arsenate of lead 3–100 was added throughout and lime as indicated. Calcium arsenate and lime 3–6–100 were substituted in the 3rd cover.
†T = Less than 0.5 per cent scab.

nized 3–100 compensated for the reduction in sulfur content of the spray in this set-up.

Hudson Valley. — Essentially the same treatments were tested in two McIntosh blocks (C. Ligatino, Ohioville, and W. A. McKiernan, Rock City) with an abundant carry-over of scab. The Rock City block was about 1 week later than the Ohioville block in seasonal development. Due to this factor, the pink, petal-fall, and 10-day

sprays were applied at Ohioville during alternating weeks to those at Rock City and, as a result, were more timely applied for critical infection periods. (See appendix.)

Six applications of the materials were made in both orchards, beginning with the pink spray. The petal-fall spray in the Ohioville orchard was made at the time of the first infection period of 20 hours (May 7). It was applied during the rain or before the trees had dried. The Rock City orchard, which was in full bloom at this time, had a wetting period of 12 hours with no protection. This established plenty of inoculum in the trees for secondary scab infection. The petal-fall spray was applied May 13. Eight infection periods, of which four were of 24 to 57 hours' duration, occurred between the petal-fall and second cover sprays, making a set-up ideal not only for primary infection but for secondary infection as well in the Rock City block. Three substantial wetting periods occurred during July to increase fruit infection.

The fruit on the unsprayed trees in both orchards was almost completely scabbed. All of the treatments at Ohioville gave almost complete control of scab, with the exception of Kolofog which had 5 per cent (Table 9, Ser. 2). The Micronized sulfur 3–100 plot had less than 2 per cent scab. The omission of the petal-fall application in a Koppers Dry 5–100 plot resulted in 15 per cent scab. The indication is that, although the treatments at this time were made in the rain during a period of from 3 to 11 hours after critical infection started, they gave adequate protection.

The data from the Rock City block show that wettable sulfurs and Fermate can be as effective as liquid lime-sulfur, or more so, although the sprays are poorly timed (Table 9, Ser. 3). Magnetic "70" paste 5–100 was decidedly more effective than Hudson Valley paste 8–100, Koppers paste 10–100, or lime-sulfur 1½–100. Fungisul, the wettable sulfur with smallest particle size, is apparently not too retentive without the addition of some material to neutralize the effect of the grinding agent which remains in the product. The Koppers Dry 5–100 is definitely inferior to Koppers paste 10–100, the same sulfur in the paste form. The plots of Micronized sulfur 5–100, the most effective of the dry wettables, had 20 per cent scab as against 28 per cent for lime-sulfur. The plot treated with Mike sulfur, a material made by the same process as Magnetic "70" paste, had 35 per cent scab. The fruit sprayed with Kolospray 6–100, a sulfur of larger particle size but containing bentonite sulfur, was

TABLE 9.—EFFECT OF TIMING OF SPRAY APPLICATIONS ON THE CONTROL OF APPLE SCAB OBTAINED WITH PASTE AND DRY WETTABLE SULFURS AND FERMATE, 1942.

TREATMENT	PERCENTAGE SCABBED FRUITS		
	Slight	Bad	Total
Ser. 1—McIntosh (F. S. McMichael, Geneva)—Inoculum Heavy—Conclusive Test*			
Untreated	0	100	100
Micronized 5–1–100	2	2	4
Micronized 3–1–100	4	4	8
Micronized 3–100, Orthex 1 pt	2	2	4
Micronized 3 + Fermate ½–100	1	1	2
Fermate 1½–1½–100	2	4	6
Fermate ¾–¾–100	4	8	12
Ser. 2—McIntosh (C. Ligatino, Ohioville)—Inoculum Heavy—Conclusive Test†			
Untreated	11	84	95
Lime-sulfur 1½–100, Sprasoy A ½ lb	T‡	T	1
Hudson Valley paste 7–100	0	1	1
Koppers paste 9–100	1	2	3
Magnetic "70" paste 5–100	0	0	0
Fungisul 4–100, Casco glue ¼ lb	1	1	2
Sulforon 5–1–100	0	1	1
Koppers Dry 5–100	0	1	1
Koppers Dry 5–100 (calyx omitted)	2	13	15
Micronized 3–1–100	1	1	2
Micronized 3–100, S.E.C. ½ pt	0	1	1
Micronized 3–100, DuPont SS 1¼ oz	0	1	1
Micronized 5–1–100	0	1	1
Mike 5–1–100	0	1	1
Kolospray 6–1–100	1	1	2
Kolofog 6–3–100	2	3	5
Fermate 1–100	T	T	1
Fermate 1–1–100	0	1	1
Fermate 1–1–100, S.E.C. ½ pt	0	1	1
Fermate 1½–1½–100	0	0	0
Fermate 2–2–100	0	0	0
Micronized 3 + Fermate ½–100	0	0	0
Ser. 3—McIntosh (W. A. McKiernan, Rock City)—Inoculum Heavy—Severe Test†			
Untreated	0	100	100
Lime-sulfur 1½–100, Sprasoy A ½ lb	11	17	28
Hudson Valley paste 8–100	12	16	28
Magnetic "70" paste 5–100	5	5	10
Fungisul 3–100, ASP ¼ lb	13	20	33
Fungisul 4–100, S.E.C. ½ pt	9	9	18
Koppers Dry 5–100	12	46	58
Koppers paste 10–100	11	19	30
Micronized 5–1–100	10	10	20
Mike 5–1–100	9	26	35
Kolospray 6–1–100	10	42	52
Kolofog 6–3–100	4	71	75
Fermate 1–1–100	7	13	20
Fermate 1½–1–100	3	6	9
Fermate 2–1–100	4	3	7

*Arsenate of lead 2–100 was added in the pre-pink and 3–100 in 5 sprays after petal fall. An application of Fermate, fixed nicotine, and oil was made in the 4th cover August 4.

†Arsenate of lead 3–100 was added after petal fall. Lime was used as indicated. Calcium arsenate 3–6–100 was substituted for the lead in 3rd cover.

‡T = Less than 0.5 per cent scab.

52 per cent scabby. Kolofog was wholly ineffective. The Fermate 1½–100 plot had 9 per cent scab as against 10 per cent for the Magnetic "70" paste 5–100, the most effective wettable sulfur.

1943 RESULTS

Hudson Valley. — Two McIntosh blocks (Frey and Simmons, Cokertown, and W. A. McKiernan, Rock City) of medium-sized trees with a very heavy carry-over of scab were used for the tests. The trees in the Rock City block were heavily fertilized which made them more susceptible to scab than the less vigorous trees in the Cokertown block.

The 1943 season was the most favorable for scab development between 1930 and 1943. Ascospores were mature and ready to discharge before the trees were in the delayed dormant stage. The first infection period occurred before the delayed dormant spray was applied. Some leaf infection occurred in all plots. One infection period came midway between the delayed dormant and the pre-pink applications, and again the unprotected foliage was infected. The pre-pink applications were made in the Rock City and Cokertown orchards May 10 and 11, respectively, in a rain which continued off and on for 3 days, keeping the trees wet for 64 hours. (See appendix.) The pink spray was applied at Rock City a week later, preceding a 24-hour infection period, while the Cokertown orchard was sprayed during the rain. There was a wetting period of 12 hours 4 days later, at which time there was abundant secondary inoculum as well as primary inoculum.

The petal-fall spray was applied at Rock City May 24 and at Cokertown May 26. There was a 24-hour infection period May 25. The next application was made a week later in each orchard, again just preceding and following a 24-hour infection period. This was followed by an all-day rain on June 7. Cover applications were made at Rock City on June 10, June 24, July 5, and July 26. Only three cover applications were needed at Cokertown and these were made June 16, July 1, and July 15. Four infection periods occurred between the first cover application and harvest.

The unsprayed trees in both orchards dropped all their fruit before harvest, due to heavy disease development (Table 10). Of the materials tested, lime-sulfur gave the best scab control, but it caused severe leaf injury and reduction in yield. The trees receiving the

TABLE 10.—PERFORMANCE OF PASTE AND DRY WETTABLE SULFURS AND FERMATE WITH AND WITHOUT SPREADER-STICKERS, 1943.

TREATMENT	PERCENTAGE SCABBED FRUITS		
	Slight	Bad	Total
Ser. 1—McIntosh (Frey & Simmons, Cokertown)—Inoculum Heavy—Severe Test*			
Untreated	0	100	100
Lime-sulfur 1½–100	1	2	3
Koppers paste 10–1–100	2	4	6
Koppers paste 8–100, Orthex 1 pt.	1	3	4
Hudson Valley paste 8 100	1	3	4
Camden paste 6–100	0	15	15
Camden paste 10–100	0	4	4
Mike 5–100	2	10	12
Mike 5–100, S.E.C. ½ pt.	1	3	4
Micronized 5 100	3	12	15
Micronized 5–100, S.E.C. ½ pt.	1	6	7
Micronized 3 + Fermate ½–100	1	5	6
Sulforon 5–100	4	14	18
Sulforon 5–100, S.E.C. ½ pt	6	6	12
Kolospray 6–100	2	27	29
Kolofog 6–3–100	3	65	68
Fermate 1–100	3	15	18
Fermate 1–100, S.E.C. ½ pt.	0	15	15
Fermate 1½–100	2	15	17
Ser. 2—McIntosh (W. A. McKiernan, Rock City)—Inoculum Heavy—Severe test†			
Untreated	0	100	100
Lime-sulfur 1½–100	1	2	3
Lime-sulfur 2–100	1	1	2
Camden paste 10 100	3	5	8
Everett paste 10–100	3	4	7
Koppers paste 10–100	5	4	9
Hudson Valley paste 8–100	4	5	9
Magnetic "70" paste 5–100	4	7	11
Micronized 5 100	7	10	17
Micronized 3 + Fermate ½–100	5	9	14
Sulforon 5–100	13	31	44
Sulforon 5 + Fermate ½–100	5	12	17

*Arsenate of lead 3–100 was added after petal fall.
†Same as above, except calcium arsenate and lime 3–6–100 were added in the 4th cover.

high concentration averaged 2.2 bushels per tree and those sprayed with the lower concentration 5.5 bushels.

The Koppers, Hudson Valley, Camden, and Magnetic "70" pastes gave commercial scab control in these critical tests when applied at recommended concentrations of about 4 pounds of actual sulfur per 100 gallons of water. The paste types proved to be more effective than the dry wettables this season when it was necessary to make some of the applications in the rain. Camden paste 6–100 gave about the same scab control as Micronized and Mike sulfurs 5–100. The

dry sulfur materials used alone failed to give adequate commercial control under the conditions of these experiments. As in previous years, those sulfur products showing the smallest particle size gave the best control when used on an equal sulfur basis. Plots in the Cokertown block that were sprayed with Micronized and Sulforon, each 5–100, had 15 and 18 per cent scab, respectively, and those in the Rock City block, 19 and 44 per cent scab, respectively. In the Cokertown block, fruit sprayed with Kolospray 6–100 had 29 per cent scab. Kolofog 6–100 was completely ineffective.

S.E.C. oil, ½ pint, definitely increased the effectiveness of the dry wettables, but its use did not minimize the importance of particle size. Micronized and Mike sulfurs with the S.E.C. oil gave scab control comparable to the sulfur pastes. The effect of adding Orthex to Koppers paste was not as striking as that of adding the S.E.C. oil to the dry wettables.

Fermate 1½–100 gave scab control on a comparable basis with the dry wettables. A combination of 3 pounds of Micronized or 5 pounds of Sulforon with ½-pound of Fermate was more effective than sulfur or Fermate alone.

A slight amount of sunscald occurred in all of the sulfur plots in Rock City orchard following the 10-day application. The temperature rose to 94°F 2 days following the application. Injury occurred on the more exposed fruits on the south side of the trees. The fruit sprayed with Fermate 1½–100 was free from sunscald. The combination of sulfur and Fermate gave almost as much injury as sulfur alone.

1944 RESULTS

Hudson Valley. — A McIntosh block (W. A. McKiernan, Rock City) with a heavy carry-over of scab was used. Ascospores were mature and ready to discharge before the trees reached the green-tip stage.

There were two infection periods before bloom. One occurred when the trees were in the green-tip stage (April 24) and the other 2 days after the pre-pink spray (May 7). Additional infections occurred May 15 and May 22, the latter 3 days after the calyx application. This rain continued off and on for 4 days and was followed on May 26 by the 10-day application. An infection period occurred June 10, 1 day after the first cover spray had been applied. A 10-hour infection period June 16 was followed by a 34-hour rain period June 20 to 22. The second cover spray was applied June 26. A 13-hour in-

fection period July 10 to 11 was followed by a 10-hour period on July 13. The third cover was applied on July 14 and was followed by rain on July 16 and 21. Eight additional showers occurred during the latter part of July and August but were not of sufficient length to serve as infection periods. Seven possible infection periods occurred this season and seven spray applications were made.

Apple scab lesions were abundant on the leaves of unsprayed trees early in the season and fruit was completely infected by July (Table 11). The plots sprayed with liquid lime-sulfur 1½–100, Camden paste (35 per cent sulfur) 10–100, and Boston paste (45 per cent sulfur) 9–100 did not have more than 3 per cent scabbed fruit. Those

Table 11.—Effectiveness of Paste and Dry Wettable Sulfurs and Fermate in a Season Favorable for Scab Development, 1944.

Treatment*	Percentage scabbed fruits		
	Slight	Bad	Total
McIntosh (W. A. McKiernan, Rock City)—Inoculum Heavy—Conclusive Test			
Untreated	0	100	100
Lime-sulfur 1½–100	1	1	2
Camden paste 10–100	1	1	2
Everett paste 9–100	2	1	3
Hudson Valley paste 8–100	4	4	8
Micronized 5–100	6	5	11
Mike 5–100	5	7	12
Sulforon 5–100	13	15	28
Fermate 1–100	5	3	8
Fermate 1½–100	2	1	3
Micronized 3 + Fermate ½–100	5	3	8

*Arsenate of lead 3–100 was added after petal fall. Lime 3–100 was used with the lime-sulfur.

of the Hudson Valley paste (50 per cent sulfur) 8–100 had 8 per cent. Micronized, Mike, and Sulforon, each 5–100, had 11, 12, and 28 per cent scab, respectively, bringing out the effect of particle size. The Camden paste plots were the only ones without arsenical injury on the foliage.

Fermate 1–100 was more effective against scab than the dry wettables but not as good as the paste types. It equaled the paste products at 1½–100. The mixture of Micronized sulfur and Fermate 3–½–100 gave better control than Micronized 5–100 and was the equivalent of Fermate 1–100.

1945–1950 results

Data are not included in detail for the period 1945 to 1950 because the experiments carried on during that period were designed,

for the most part, to obtain information on the performance of organic materials. Since this treatise is basically an attempt to show the effectiveness of wettable sulfurs under a variety of conditions over a period of years, only a brief resume of the data for 1945–50 that are more or less applicable to this bulletin is given here (Table 12).

Table 12.—Effectiveness of Wettable Sulfur for the Control of Apple Scab on McIntosh, 1945–50.

Treatment	Percentage scabbed fruits					
	1945	1946	1947	1948	1949	1950
Western New York						
Micronized 5–100	—	6	23	38	4	22
Fermate 1½–100	—	2	T*	5	—	6†
Hudson Valley						
Micronized 5–100	40	66	3	22	2	4
Everett Paste 9–100	38	59	—	34	2	3
Fermate 1½–100	23	46	2	7	1	2

*T = Less than 0.5 per cent scab.
†Fermate was applied to a part of the wettable sulfur plots in the cover sprays.

Western New York. — In a moderate test against scab on McIntosh, wettable sulfur was effective in 1946. There was a heavy carry-over of inoculum in the block from the 1945 season. Poor scab control was obtained with a wettable sulfur in 1947 and 1948 due to lack of protection during frequent rains. This could be attributed either to lack of retention or to poor timing since the plots receiving eradicative materials were clean for the most part.

The block in 1947 had a light carry-over of inoculum and was considered only a fair test.

Although there were 17 infection periods with about 14 inches of rain during the spraying season of 1948, the really vulnerable period was between the pink application and first cover. The scab count on the fruit at the time of the June drop was the same as it was at harvest. The June drop was considerably higher with the sulfur treatments than with Fermate.

The percentage scab in 1950 was rather high, but the count is mostly slight scab and is probably the result of spraying from the tank as the test was part of a spray concentrate experiment. It is to be noted that Fermate consistently gave better scab control than the wettable sulfurs.

Hudson Valley.—There was a heavy carry-over of scab in the blocks of McIntosh used in 1945, 1946, and 1948 and moderate to light in those of 1947, 1949, and 1950. The poor scab control obtained in 1945 was due to a combination of abundant inoculum and twice normal rainfall during May, June, and July. The fact that no fungicide was used after the third cover was a contributing factor.

In 1946, a 10-day spray schedule was followed in a McIntosh orchard with a heavy carry-over of inoculum. The high scab count indicated that more frequent applications are necessary to give protection under such conditions when wetting periods are frequent or the rainfall high.

In 1948, the sulfur materials again failed to withstand prolonged rain periods and a heavy carry-over of scab. Sulfur fungicides, properly timed, in orchards with moderate to light carry-over of scab gave adequate control in 1947, 1949, and 1950. Fermate proved to be more effective than the wettable sulfurs in the critical tests.

DISCUSSION AND CONCLUSIONS

FACTORS INFLUENCING CHOICE OF FUNGICIDE

The results of 15 years of orchard experiments with materials for control of apple scab indicate that selection of a fungicide and the concentration to use are determined by factors which influence scab development, such as orchard location, tree vigor and variety, abundance of primary inoculum, and prevailing weather conditions. If the combination of these factors is favorable for scab development, sulfur materials of smallest particle size must be used at a concentration to give maximum redistribution in order to obtain adequate control. If these factors are unfavorable for scab development, even the less effective products with low inherent toxicity or retentive properties will give satisfactory results.

Available spray and dust equipment, other disease and insect problems, the compatibility of various fungicides and insecticides in relation to control and injury to fruit or tree, and the relative cost of various fungicides may be additional factors in the selection of a fungicide for scab control.

TIMING APPLICATIONS

The seasonal variation from year to year in New York State makes it difficult to recommend a definite number of fungicidal spray applications which will give effective scab control under all condi-

tions and which at the same time will be economical. For example, in 1941 and 1942, the delayed dormant and the pre-pink sprays were not necessary since there was no rain during the period between green tip and pink. Although weather forecasting is considerably improved, it seems that the grower with a large acreage of susceptible varieties in a set-up that constitutes a scab problem should plan on a complete spray schedule unless adequate duster or spray equipment is available.

The pre-cover sprays, which have given adequate protection in experimental plots with the better wettable sulfur materials and now are accepted in practice, consist of the delayed dormant, pre-pink, pink, petal fall, and, possibly, 10-day. However, in seasons of frequent rains, extra applications may be needed between any of these regular sprays in order to protect new growth. If growth is rapid before bloom, it may be that only two pre-blossom sprays need be applied. A spray is recommended between the pink and petal fall if the bloom period is lengthened as the result of cold weather. The timing of the 10-day spray, which is frequently applied between petal fall and first cover, depends, in part, upon the development of curculio, red-banded leaf roller, and codling moth. Timing these applications to precede the rain periods so as to protect new growth rather than on a strict host-development basis has added greatly to the effectiveness of the program. Growers should keep in mind that some applications are to be regarded in the nature of an insurance measure.

A fungicide is included in the cover sprays applied in June if there is danger of primary infection. It may be included in the other cover sprays, particularly the last one in August, if there is sufficient scab infection to justify it. While these sulfur materials were applied in three or more of the cover sprays in these plots, copper materials or Fermate were substituted by growers, particularly in western New York, in high temperature areas and where summer oil was being used for codling moth control. As stated elsewhere, this phase of our work is not reported here.

Wettable sulfurs and Fermate rarely function as eradicants as does lime-sulfur. To obtain perfect control with protective fungicides, it is necessary to have all susceptible host tissue covered at the time of an infection period. When these studies were begun it was considered necessary to have the spray on the tree and dry before rain started. As work progressed on the setting and redistribution of

materials, it was found that good scab control could be obtained with the paste type of wettables and with dry wettables that had been improved by reducing the particle size and adding proper conditioners when they were applied during the rain or shortly afterwards while the trees were wet. This was demonstrated in 1940, 1942, and 1943 (Table 7, Ser. 2; Table 9, Ser. 1; and Table 10, Ser. 1 and 2).

In 1940, Hudson Valley paste, with or without Orthex, gave protection when it was applied in the early stage of a 1-inch rain and an infection period of 32 hours. The fact that wettable sulfurs applied after the infection period gave control indicates that in some set-ups they are effective after wetting periods of greater duration than the 8 to 10 hours commonly observed.

In 1942, experimental plots received the petal-fall application on May 7 during a rain totaling 0.70 inch and with a wetting period of 20 hours at 50° to 60°F. Trees which did not receive this petal-fall spray developed 15 per cent fruit infection, while all of the standard treatments held scab to about 1 per cent. The foliage of the trees in the lime-sulfur plots sprayed under these conditions was severely injured.

Similar results were obtained in 1943 when frequent rains necessitated spraying in the rain in order to provide adequate protection (Table 10, Ser. 1 and 2). As would be expected under these conditions, wettable sulfur is most effective at the higher concentration or with the addition of oil-type stickers (Table 10, Ser. 1).

Tests on potted trees grown in the greenhouse indicated that lime and Orthex were more effective in increasing the retention of wettable sulfur. To obtain the full value of fungicides applied in the rain, the application must be completed before infection has taken place.

INFECTION PERIODS

Favorable environmental conditions for apple scab infection by either ascospores or conidia consist of certain minimal periods of moisture at any given temperature. Keitt and Jones (20) worked out the relation between temperature and duration of moisture on infection under greenhouse conditions with an abundant source of inoculum. Under most field conditions, a somewhat longer period is required.

A fair indication of the requirements for infection in the field has been secured by checking the length of wetting periods against

the prevailing temperature and the amount of scab which developed on the unsprayed trees under orchard conditions over a period of years. (See appendix.) These observations indicate that in orchards with an abundant source of inoculum, some infection can be expected if the trees are kept wet for 30 hours at 40°F, 20 hours at 45°F, 12 hours at 50°F, and 8 to 10 hours at 55° to 75°F. Somewhat longer wetting periods are required at temperatures higher than 75°F. While some infection may result with the above combinations, in general, the longer the moist conditions are maintained the greater will be the number of scab lesions, especially on the fruit as it reaches maturity. These figures agree closely with observations reported by Mills (21).

Continuous wetting was not necessary for infection, especially when the weather was cloudy and the temperatures between the rain periods were fairly low.

PARTICLE SIZE

The effectiveness of wettable sulfur materials depends to a large extent on particle size and the conditioning agents, both of which influence their toxicity to the fungus and their adhesion to host tissue. Those products with the smallest particle size have consistently given the best scab control. This is due to the greater toxicity of the more finely divided sulfur, to the more uniform coverage of host tissue with a given weight of material, and to the greater resistance to removal by rain (6, 13).

Generally speaking, the paste forms of wettable sulfurs have been consistently more effective than the dry forms. The dried forms of flotation paste and Magnetic "70" did not give scab control equal to that of the paste forms, probably due to physical changes which occurred during the drying process and to the addition of conditioning agents (Table 4, Ser. 4; Table 7, Ser. 1 and 2; and Table 9, Ser. 2). The individual particles of the dry product tend to agglomerate on being placed in water so that they take on the properties of large particles. The relative value of the dry wettables in scab control was in inverse proportion to the average diameter of the sulfur particles. Micronized (3.7μ), Mike (5.3μ), Sulforon (6.6μ), Kolospray (7.7μ), Magnetic-Spray (8.3μ), and Sulcoloid (14.2μ) gave scab control in that order (Table 4, Ser. 4; Table 5, Ser. 3; Table 7, Ser. 1 and 2; Table 8, Ser. 1; Table 9, Ser. 3; Table 10, Ser. 1 and 2; and Table 11). The validity of this trend is supported by the fact

that the control obtained with three identical sulfurs of 3.7, 6.6, and 10.3 microns (average surface diameter) decreased as the particle size increased (Table 4, Ser. 5a and 5b; Table 5, Ser. 3; and Table 6, Ser. 2; Fig. 1). Doubling the concentration of the 10.3-micron sulfur did not compensate for the greater toxicity of the 3.7- and 6.6-micron materials (Table 6, Ser. 2). The effect of particle size evidently is accentuated under conditions favorable for scab development. Seasonal weather conditions, inoculum potential, timing of sprays, varietal susceptibility, adjuvants, and concentration of toxicant are definite factors.

MINIMAL DOSAGE

There is a minimal concentration for even the best sulfur materials when conditions are favorable for scab development. This is roughly 4 pounds of actual sulfur in 100 gallons of water for the paste types and 5 pounds for the dry types. The flotation sulfur pastes are generally effective at 10–100 and the better dry wettables, such as Micronized, at 5–100. The dry wettables with an average particle size greater than 6 microns should be used 6–100 to 8–100. It may be that the sulfur content of any of the materials should be increased 2 pounds or so in a season of abnormally high rainfalls and frequent infection periods. Orchard tests indicate that if rapid coverage is to be made, the concentration should be increased and the tops of the trees thoroughly covered. It is essential to have sufficient sulfur for redistribution (12). The failure of Kolofog in critical tests, except when applied immediately before the infection period, is attributed, in the main, to the fact that at 6–100 there are but 2 pounds of sulfur.

The effective concentration of a material depends not only upon the inherent toxicity and physical properties of the material, but upon the timing, thoroughness, and frequency of application, the carry-over of scab, and weather conditions.

ADJUVANTS[3]

Materials of one kind or another are frequently added to fungicides to correct injury, to make them flowable or wettable, to increase their suspension properties or to bring about flocculation, and to spread them or to increase their retention. Goulac or Bindarene flour and the catalytic mixtures (manganese sulfate and spread-

[3]Grateful acknowledgment is made to Doctors G. L. Mack and A. W Avens of this Station for their assistance in making the chemical analyses reported here.

ing agent), with or without sulfur decreased the injury caused when the mixture of lime-sulfur and arsenate of lead was used, but they also lowered the eradicative value of the mixture so that the reduction in injury in critical set-ups was not sufficient to justify their use.

Lime was found to be the most practical corrective for spray injury. Work on greenhouse-grown trees showed that lime 1–100 hastened the setting of wettable sulfurs and materially increased their retention. This is a function of flocculation. The addition of lime improved the effectiveness of freshly prepared dry wettables. The original deposit of sulfur or lead arsenate was decreased by the addition of one to the other, and each was affected as the lime content was increased, particularly as the concentration approached 6–100 (Table 13).

Spreader-stickers materially affect the original deposits as well as retention (Tables 13 and 14). Basically, a minimum of the wetting and spreading agent with no residue builder is desirable. The addition of too much or the wrong kind of spreader-sticker can result in low initial deposit, little retention, or a selective action as to the

Table 13.—Relative Sulfur and Lead Residues Resulting from the Application of Fungicide and Insecticide Alone and in Combination, With or Without the Addition of a Spreader-Sticker, Rome Beauty, 1939.

Treatment*	Original deposit†		Residue after 1½ inches rain†	
	Foliage, sulfur	Fruit, lead	Foliage, sulfur	Fruit, lead
Sulfur 5–100	139	Trace	40	Trace
Sulfur 5 + lead 3 + lime 3–100 (standard)†	100	100	42	49
Sulfur 8 + lead 3 + lime 3–100	151	68	49	35
Sulfur 5 + lead 3 + lime 3–100 + Filmex ⅓ lb	87	75	31	48
Sulfur 5 + lead 3 + lime 3–100 + DuPont SS 1½ oz	111	99	40	59
Sulfur 5 + lead 3 + lime 3–100 + S.E.C. ½ pt	107	95	40	59
Sulfur 5 + lead 3 + lime 3–100 + S.E.C. 1 pt	145	66	52	53
Sulfur 5 + lead 3 + lime 3–100 + Orthex 1 pt	108	95	40	64
Sulfur 5 + lead 3 + lime 3–100 + Orthol K 1 pt. + Sprasoy A ½ lb	147	67	56	52
Lead arsenate 3–100	—	130	—	77
Lead arsenate 3 + lime 3–100	Trace	130	Trace	67
Lead arsenate 3 + lime 6–100	—	87	—	35

*Sulfur = Micronized sulfur; lead = Lead arsenate. Concentrations expressed in amounts for 100 gallons of water.

†Data expressed as percentages of the standard treatment (Micronized sulfur 5–100, lead arsenate 3–100, and lime 3–100) which is set at 100.

TABLE 14.—RELATIVE SULFUR RESIDUES OBTAINED WITH THE ADDITION OF CERTAIN ADJUVANTS ON ROME BEAUTY FOLIAGE, 1938.*

TREATMENT	SAMPLING DATE AND RAINFALL		
	Aug. 31, 0.00 in.	Sept. 15, 1.70 in.	Sept. 20, 5.23 in.
Mike 5–100 (standard)	100	42	39
Mike 5 + Orthex 1 pt	146	78	71
Mike 5 + lime 3	90	49	36
Mike 5 + lime 3 + S.E.C. 1 pt	108	76	67
Hudson Valley paste 8–100 (standard)	100	60	56
Hudson Valley paste 8 + Orthex 1 pt	135	94	85
Hudson Valley paste 8 + lime 3	111	68	56
Hudson Valley paste 8 + lime 3 + S.E.C. 1 pt	160	96	83

*Data expressed as percentages of the standard treatments, Mike 5–100 and Hudson Valley paste 8–100, which are set at 100. Concentrations expressed in amounts for 100 gallons of water.

fungicide and insecticide which could make a good material comparatively ineffective. The spreader Filmex gave a considerably lower initial deposit than DuPont Spreader-Sticker (Table 13).

DuPont Spreader-Sticker, 1½ ounces; S.E.C. oil, ½ pint; and Orthex, 1 pint, which represent a wide range in spreader-stickers, gave essentially equivalent initial deposits that exhibited comparable retention of sulfur and arsenate of lead when added to Micronized sulfur 5–100. Increasing the concentration of the S.E.C. oil from ½ pint to 1 pint to 100 gallons may not only result in run-off but may bring about a selective action toward the sulfur. That is, the S.E.C. oil increased the deposition of the sulfur and decreased deposition of arsenate of lead. The same trend was noted when the Orthol K, Sprasoy A, and lime mixture were added as a residue builder.

Although greenhouse work showed that DuPont Spreader-Sticker was definitely not a sticker in the same category as the oil stickers, the orchard data indicate that the increased spray load, probably due to better spreading, may compensate for that obtained with the residue builders when applied under average conditions (Table 7). A spreader-sticker is generally used solely to obtain a better finish of fruit. While chemical analyses and orchard data show that there is an advantage in some set-ups from adding an oil-type spreader-sticker as a general practice, the same results may be obtained by increasing the concentration of the sulfur (Tables 7, 10, 13, 14).

Orthex is not suggested for use as a residue builder, but rather to permit spraying under poor drying conditions or in the rain. While

flotation sulfur paste, particularly with the addition of lime 1–100, has given good results without Orthex in many instances, greenhouse and orchard experiments show improved control with the use of Orthex. Sulfur fungicides flocculated with lime show increased retention. Lime 1–100 will prevent the Orthex from reducing the effectiveness of the sulfur. Poor results obtained in early tests with Orthex are attributed to the fact that no lime was added. Good agitation must accompany flocculated sprays. A suspending agent, such as soybean protein flour, will keep most materials in suspension but "setting" will be very slow. The purpose of Orthex is to throw the spray material out of suspension immediately the drop of spray forms on the leaf or fruit and, in the case of rain, clear water runs off. Orthex should not be used later than the petal-fall or 10-day spray to avoid injury from high temperature. A vegetable oil, such as S.E.C. oil, is preferable as a residue builder throughout the season as it may be used at higher temperatures with less danger of sulfur injury.

WETTABLE SULFURS COMPARED WITH LIME-SULFUR

The results of fungicide tests for apple scab control in New York during the years 1930 to 1934 have been reported (2, 4). During that period, wettable sulfur materials were in their infancy and were generally considered inferior to lime-sulfur for scab control. It was shown that flotation sulfur paste gave adequate commercial scab control when properly timed and thoroughly applied under conditions most favorable for scab development. Growers were using the material throughout the season and it was recognized that the use of wettable sulfur resulted in better foliage and finer finish of fruit. Wettable sulfurs did not cause the fruit to drop in midseason as did lime-sulfur, although the fruit on the Kolofog plots dropped early at harvest time. While the experiments indicated that dry wettables could be effective, they were seldom used throughout the season but were beginning to replace lime-sulfur in the cover sprays.

During the 10-year period of the investigation reported here, the dry wettable products were greatly improved in regard to particle size and conditioning agents. Field tests demonstrated that they gave scab control approximating that of the pastes. Now they are used throughout the season in commercial orchards with results equal to those obtained with lime-sulfur.

The direct evaluation of apple scab control data over a period of

years can best be made by comparing the degree of control secured with the various materials with liquid lime-sulfur, since it was used as a standard in most seasons (Table 15). A comparison between materials in a given year is more accurate than the average. The fact that lime-sulfur is unlike the wettable sulfurs in that it is an eradicant as well as a protectant must be taken into account.

TABLE 15.—RELATIVE APPLE SCAB CONTROL ON MCINTOSH OBTAINED WITH LIQUID LIME-SULFUR AND VARIOUS WETTABLE SULFURS IN SEVEN EPIDEMIC SCAB YEARS.*

TREATMENT	SULFUR, LBS.	1937, HV	1938, HV	1940, HV	1940, W	1941, HV	1942, HV	1943, HV	1944, HV	AVERAGE
Lime-sulfur 1½–100	4.0	100	100	100	100	100	100	100	100	100
Magnetic "70" paste 4–100	3.2	—	100	103	95	97	—	—	—	98
Magnetic "70" paste 6–100	4.2	—	—	103	101	101	112	96†	—	102
Camden paste 6–100	2.1	—	95	101	95			88	—	95
Camden paste 10–100	3.5	—	102	102	—	—	—	98	101	101
Koppers paste 6–100	2.4	96	97	—	87	—	—	—	—	93
Koppers paste 10–100	4.0	99	103		100	—	97	97		99
Hudson Valley paste 8–100	4.0	—	—	—	—	101	100	99	95	99
Micronized 5–100	5.0	—	98	102	98	100	111	88	92	98
Mike 5–100	5.0	—	100	95	88	91	90	90	90	92
Magnetic-Spray 6–100	6.0	83	95	—	—	—	—	—	—	89
Kolospray 6–100	5.1	—	—	97	—	—	67	73	—	79
Kolofog 6–100	2.1	—	—	—	47	93	35	33	—	52

*The percentage of apple scab control obtained with liquid lime-sulfur was set at 100 and the other materials were rated accordingly. HV = Hudson Valley; W = Western New York.
†Magnetic "70" paste used at 5–100 in 1943.

The paste products gave scab control equivalent to that of lime-sulfur when used on an equal sulfur basis under conditions of heavy inoculum and weather conditions favorable for scab development. Even in epidemic scab years like 1943 and 1944, they gave adequate protection. Micronized sulfur was as good as lime-sulfur in three out of seven tests, was slightly less effective in two tests, and fell to about 90 per cent of the standard in 1943 and 1944, probably because of a change in the wetting agent used. The paste products used at low concentrations (2 to 3 pounds of actual sulfur to 100 gallons) averaged from 93 to 98 per cent of the standard. They were better than any of the dry materials except Micronized which had an average of 98 per cent. Mike averaged 92 per cent and, due to a change of formula, was the equivalent of Micronized in 1943 and 1944. Magnetic-Spray, Kolospray, and Kolofog, at 6–100, averaged

89, 79, and 52 per cent of the standard, respectively, and cannot be considered effective under conditions favoring scab development.

Fermate 1½–100 has given scab control as good as or better than Micronized sulfur 5–100 with comparatively little injury when used with arsenate of lead (Tables 8, 9, 10, and 11).

MIXED FUNGICIDE PROGRAMS

The necessity of a mixed fungicide spray program is determined by such factors as efficiency of spray equipment, susceptibility of varieties to scab, other diseases, spray injury, weather factors, and the insect problems. If apple scab is the major problem in the orchard, one good wettable sulfur may be used throughout the season. Most of the fungicide tests repored here were so conducted. Mixed programs of sulfur fungicides can be employed to advantage under commercial orchard conditions. The paste types of wettable sulfur or the more retentive dry forms should be used to give protection through the period in which the primary inoculum is the major factor, with the coarser dry materials applied at the time of greatest danger of sulfur injury from high temperatures.

The paste sulfurs have given more sunscald than the dry sulfurs. The data show that, for all practical purposes, severe sulfur injury can be had with any sulfur material should extremely high temperatures occur before rain (Tables 16 and 17). Magnetic "70" may be expected to be one of the worst in this regard. It has caused rather severe fruit russet. Dusting with sulfur when there is little or no protection and possible infection periods are at hand is an excellent practice. Lime-sulfur has caused so much injury and re-

Table 16.—Spray Injury to McIntosh, R. I. Greening, and Baldwin Caused by Certain Fungicides under Conditions of High Temperature, George Mead Orchard, Barker, N. Y., 1936.*

Treatment	McIntosh		R. I. Greening		Baldwin	
	Leaves injured, no. per terminal	Fruit scalded, per cent	Leaves injured, no. per terminal	Fruit scalded, per cent	Leaves injured, no. per terminal	Fruit scalded, per cent
Lime-sulfur 1–100	2	2	Trace	Trace	4	12
Lime-sulfur 2–100	11	11	6	27	7	68
Koppers paste 8–100†.	3	15	0	11	5	28
Copper materials‡....	0	0	0	0	0	0

*Data were taken July 21 from southeast side where injury was most severe.
†Koppers paste = Koppers flotation sulfur paste.
‡Copper materials = Bordeaux mixture 2–3–100, Oxo-Bordeaux 6–100, Coposil 3–100, and Z-O 2–100.

TABLE 17.—FOLIAGE AND FRUIT INJURY OF BALDWIN CAUSED BY CERTAIN FUNGICIDES UNDER CONDITIONS OF HIGH TEMPERATURE AND THE EFFECT ON FRUIT SIZE AND YIELD, 1936.*

TREATMENT	LEAVES INJURED, NO. PER TERMINAL	FRUIT SCALDED, PER CENT	YIELD, BUS. PER TREE	FRUIT SIZE, NO. PER BU.
G. Mead Orchard, Barker, N. Y.				
Lime-sulfur 1–100	4	10	22	163
Lime-sulfur 2–100	7	42	6	193
Koppers paste 8–100†	5	22	20	181
Kolofog 6–100	8	27	—	178
Bordeaux 2–3–100	0	0	20	110
A. T. Miller Orchard, Waterport, N. Y.				
Lime-sulfur 1–100	3	9	15	160
Lime-sulfur 2–100	9	34	8	219
Koppers paste 8–100	7	38	11	188
Magnetic-Spray 6–100	8	29	12	224
Kolofog 6–100	9	33	—	184
Bordeaux 2–3–100	0	0	19	141

*Leaf and fruit counts made from southeast or injured side of tree.
†Koppers paste = Koppers flotation sulfur paste.

duction in yield when it was included in the regular spray schedule, even though only applied before bloom, that it is now only suggested to eradicate scab at the time of the infection period or after the lesions are fully developed. Recommendations for its application at this time are made with reservation because danger of injury is so great, particularly at a time of frequent rains. While the injury can be minimized by applying the material with a broom, spray-mast, or speed-sprayer type of machine, such comparatively noninjurious materials as the phenyl mercurics and Phygon have now become available for this purpose in the pre-cover sprays.

A mixture of the wettable sulfur, one-half concentration, and Fermate ½–100 is recommended in the regular pink, calyx, and 10-day sprays if it is necessary to control the rust fungi. Fermate ½–100 alone is suggested for special sprays for rust control and 1½–100 for the control of scab after petal fall (Tables 8 to 11). Fermate has replaced bordeaux and Coposil which were used commercially in the cover spray complex during most of the years for which these data are given. The substitution of Fermate in the spray schedule after bloom will tend to minimize the russeting factor on Delicious and Golden Delicious (14).

Since the number of fungicides that can be used in the summer spray program is limited and since the spray program is more com-

plex, it seems pertinent to give a brief account of the status of copper materials. The remarks are based upon field tests conducted in many of the same orchards as the sulfur fungicides, particularly in western New York (2, 3, 4, 5, 7, 8, 13). Bordeaux 1½–9–100 was found to be effective against scab and the least injurious formula to use in the cover sprays to prevent russeting before the fruit hairs are sloughed off or to minimize foliage injury in August. Since russeting of the fruit is the result of injury to the hairs, the high lime content is particularly essential in the first cover. A high magnesium lime bordeaux gave about the same russeting as a high calcium one. A minimum of 2 weeks, preferably 3 or 4, should elapse after bloom before the first application of bordeaux is made. The varietal factor is large. McIntosh are not often injured commercially at the 2-week period, whereas Cortland probably would be completely russeted. The mixture of bordeaux ¾–6–100 and a wettable sulfur, one-half strength, was about as safe in the early cover sprays as any other material, but the sulfur residue was too high if summer oil were to be used or during high temperatures. The addition of a good spreader was essential. An oil-type spreader-sticker decreased the injury at the time of application, but, through increasing the retention or the copper load, frequently resulted in more injury, particularly to the foliage, later on in the season. Oxo-bordeaux 6–12–100 in the first cover and 6–6–100 in the other covers gave very good results, although it was not nearly as adhesive or as effective as bordeaux. It did give a smooth residue film on the fruit in the summer sprays, however. As intimated above, neither the bordeaux nor the Oxo-bordeaux can be generally recommended before the first of July.

Out of some 14 commercial brands of so-called "insoluble" copper materials which included copper ammonium silicates, oxychlorides, oxides, phosphates, oxalates and basic copper sulfates, and two dried bordeaux materials tested, Coposil (copper ammonium silicate and zinc) was the only one to find a place in the spray schedule on apples. Coposil 1½–3–100 with Orthex, 1 pint, is suggested for the first cover and Coposil 1½–1½–100 with some good spreader-sticker for the other covers. Coposil 2–2–100 is indicated if no sticker is used. Coposil 1–1–100 was found to be most satisfactory to use with summer oil and the fixed nicotines. While the lime tends to free the nicotine, it does not interfere with codling moth control when oil is used and it does minimize copper injury and give a better finish of

fruit. Z–O (copper ammonium silicate) was equally safe and effective. It is considered that the insoluble coppers are safer, not so much because they are less soluble than bordeaux but because they do not adhere. Generally speaking, these bordeaux substitutes cannot be tolerated on apples if their total copper content exceeds 0.4 to 0.5 pound of actual copper per 100 gallons of spray even though 2 pounds hydrated lime are added for each ¼-pound actual copper. Tests with Coposil and Z–O in a range of particle sizes indicated that injury became the limiting factor if the average particle size exceeded 10 microns. Orchard data indicated that the copper particles under 4 microns or so caused the injury. As indicated, materials with an inherent copper content of 25 per cent or less were safer than those in the range of 50 per cent or higher. A given copper made by different companies did not exhibit the same toxicity. A 50 per cent copper material does not necessarily have twice the toxicity of a 25 per cent compound. A copper spray such as the copper phosphate-lime-bentonite mixture that has the copper tied up tightly fails to give disease control.

Of the many copper correctives tested, it may be said that, for all practical purposes, there is no other as cheap and effective as hydrated lime. Calcium carbonate was as good a corrective as the uncarbonated lime. The addition of lead arsenate increased the amount of russeting. Conditioners play a part in the degree of injury, but when lime is used as a corrective, they are of small importance, except perhaps for bentonite which should be omitted. The addition of an oil sticker functions the same as for the bordeaux.

STATUS OF FUNGICIDES AT END OF 1950 SEASON

There have been seasons since 1944, in which wettable sulfurs, as a group, gave poor control of apple scab in comparison with some of the organic fungicides. This has been attributed to insufficient retention and poor timing or to lack of protection at the critical infection periods. Comparatively high concentrations or the addition of stickers did not sufficiently improve scab control.

The organics can be divided into two classes, *viz.*, those that are basically protective like the wettable sulfurs and those that are protective but also are eradicative when applied after the infection period as is lime-sulfur. Fermate and Crag 341 are representatives of the first group and Tag Fungicide No. 331, Puratized Agri-

cultural Spray, Phygon, and Bioquin I of the second group. Fermate gives scab control comparable to that of dry wettable sulfur in New York State. It is more effective on the fruit than on the foliage. It is possible to have a greater yield and less fruit russet from the use of Fermate than from a wettable sulfur. Poorer color may be a problem, particularly if the ground applications of fertilizer are not adjusted according to the number of applications of Fermate. Objectionable residue can be had with indiscriminate spraying without regard to concentration, time of season, or spreading agent.

Crag 341 will withstand more rainfall than any other material tested, but injury may be a serious factor, especially on Greening and Delicious. It has possibilities in the cover sprays when danger of russeting is at a minimum but appears to be incompatible with lead arsenate.

Tag and Puratized are fair protectants and are as effective as lime-sulfur or more so when applied after infection periods without the danger of serious injury. They may cause the leaves to drop if applied at the time scab lesions appear. They are for pre-bloom sprays only and have caused little fruit russet. They should not be applied following Fermate or during hot weather.

Phygon has poor retention, but it is moderately effective against scab as a spray or dust when applied after infection periods. Injury after repeated applications has been a serious factor; however, this should be of no consequence if the material is used only for emergencies. Phygon can be applied after the petal-fall spray whereas the materials containing mercury cannot.

Bioquin I is one of the best of the new materials, but it is not effective at the concentration at which it would have to be used because of cost.

Orthocide 406, in preliminary tests, has shown that it is a fair protectant and a very mild eradicant. Indications are that it may cause less fruit russet and give a higher quality apple than most fungicides. Lime must not be used with this material. Indications are that it is more of an "all-around" material than the other organics.

Briefly, it would appear that all of the new materials can be more or less injurious, particularly if more than two or three successive applications are made, and they are expensive. It would seem that wettable sulfur is still the basic fungicide on which to build a spray schedule, especially with spray concentrates entering the picture

and the complex nature of the insecticide program at this time. The phenyl mercuries have given a minimum of fruit russet in the pre-cover sprays. Fermate is the best of the substitutes for use after bloom and has resulted in less fruit russet when arsenate of lead was used. It would look as if mixtures of sulfur or Fermate and the phenyl mercuries and phygon were the best way to achieve maximum protection and still have appreciable eradicative possibilities with a minimum of injury. Crag 341 may have a place eventually in the spray schedule alone or in combination with the above materials. Each season brings out weaknesses in these materials as to injury, effect on the host, finish of fruit, and compatibility with each other or with insecticides.

SUMMARY

The results of 10 years of orchard testing of fungicides for apple scab control in New York State indicate the importance of orchard and weather conditions in relation to scab development and, therefore, to the type of fungicidal program required.

Records of maturity dates of ascospores for the period 1930 to 1944 show that ascospores were mature each year by the time any susceptible host tissue was exposed on the McIntosh variety.

The time of the first infection in relation to host development was determined by the occurrence of sufficient rain to give an infection period rather than ascospore maturity. During a period of 15 years it was observed that the first infection on McIntosh in the Hudson Valley occurred in six seasons when the host was in the green tip to delayed dormant stage, in five seasons during the pre-pink or the pink stage, and was delayed until bloom or calyx in four seasons due to dry spring weather.

The most critical period for primary scab infection was found to be during the latter part of April, May, and June. The earliest date of ascospore discharge observed was April 6 and the earliest date of complete discharge was June 10.

Eight fungicide applications timed to protect the new growth during infection periods proved sufficient for the control of scab in McIntosh orchards having an abundant primary inoculum in years favorable for disease development.

Magnetic "70" and the flotation sulfur pastes at concentrations of about 4 pounds of actual sulfur per 100 gallons were as effective, on the average, against scab as lime-sulfur over a period of 7 epidemic

scab years. Stauffer's Magnetic "70" sulfur paste was found to be the most retentive of all the wettable sulfurs that approach the requirements for redistribution. Micronized was the only one of the dry wettable sulfurs tested which gave a consistent performance and approached the effectiveness of the paste types.

The fungicidal effectiveness of ground wettable sulfurs was found to be inversely proportional to the size of the particles. Wettable sulfurs should have an average particle size of less than 5 microns. Increasing the concentration of products containing coarse sulfur particles did not compensate for the particle size factor. To obtain disease control under environmental conditions favorable for scab development, a minimum concentration of 4 to 5 pounds of actual sulfur per 100 gallons of the best sulfur material was required.

Oil-type stickers improved the effectiveness of wettable sulfurs under some conditions. While wettable sulfur, particularly the paste type, may give protection when applied during rain periods, the addition of Orthex is suggested. Hydrated spray lime increased the rate of setting of wettable sulfurs and improved their retention. The kind and amount of adjuvants added are vital factors in the initial deposit and retention of spray materials.

It was found that Coposil and Fermate could be substituted in the spray program to control certain other diseases, to avoid high temperature injury, or to avoid injury when it was necessary to use certain insecticides which are not compatible with sulfur.

LITERATURE CITED

1 Hamilton, J. M. The spraying program and the control of apple scab in the Hudson Valley. *Proc. New York State Hort. Soc.,* ***77:*** *209–212. 1932.*

2 ————. Recent investigations on the control of apple scab in the Hudson Valley. *New York State Agr. Exp. Sta. Bul. No. 604. 1932.*

3 ————. Further studies on the fungicides for scab control in the Hudson Valley. *Proc. New York State Hort. Soc.,* ***79:*** *197–201. 1934.*

4 ————. Studies of apple scab and spray materials for its control in the Hudson Valley. *New York State Agr. Exp. Sta. Tech. Bul. No. 227. 1935.*

5 ————. The use of copper sprays in the apple orchard. *Proc. Maryland State Hort. Soc.,* ***38:*** *75–82. 1936.*

6 ————. Recent investigations on the control of cedar-apple rust in the Hudson Valley. *New York State Agr. Exp. Sta. Bul. No. 678. 1937.*

7 ————. Summer fungicides on apples in western New York. *Proc. New York State Hort. Soc.,* ***82:*** *39–48. 1937.*

8 ———— and Palmiter, D. H. Apple scab control in 1937. *Proc. New York State Hort. Soc.,* ***83:*** *22–29. 1938.*

9 ————. Apple fungicides. *Proc. New York State Hort. Soc.,* ***86:*** *44–53. 1941.*

10 ————. Comments from the study of fungicides in 1941. *Proc. New York State Hort. Soc.,* ***87:*** *41–42. 1942.*

11 ———— and Palmiter, D. H. Spray materials and new concepts in the control of apple scab and cedar-apple rust fungi. *Proc. New York State Hort. Soc.,* ***88:*** *19–22. 1943.*

12 ————, Mack, G. L., and Palmiter, D. H. Redistribution of fungicides on apple foliage. *Phytopath.,* ***33:*** *5. 1943.*

13 ————, Palmiter, D. H., and Mack, G. L. Particle size of sulfur and copper fungicides in relation to apple scab and cedar-apple rust control. *Phytopath.,* ***33:*** *533–550. 1943.*

14 ———— and Palmiter, D. H. Apple scab, cedar-apple and quince rust, fruit russet, and cherry leaf-spot control in 1943. *Proc. New York State Hort. Soc.,* ***89:*** *27–34. 1944.*

15 ————, Palmiter, D. H., and Mack, G. L. Tests with new organic fungicides on orchard fruits. *Phytopath.,* ***34:*** *1002. 1944.*

16 ———— and Mack, G. L. Fungicides for orchard fruits. *Proc. New York State Hort. Soc.,* ***92:*** *9–17. 1947.*

17 ————. Progress report on fungicides for apples, cherries, and peaches in 1947. *Proc. New York State Hort. Soc.,* ***93:*** *13–20. 1948.*

18 ————. Results of fungicide tests for apple scab control in 1948. *Proc. New York State Hort. Soc.,* ***94:*** *13–20. 1949.*

19 ————. Spray concentrates compared with standard concentrations for the control of apple scab and cherry leaf spot in 1950. *Proc. New York State Hort. Soc.,* ***96:*** *158–165. 1951.*

20 Keitt, G. W., and Jones, L. K. Studies of the epidemiology and control of apple scab. *Wisconsin Agr. Exp. Sta. Res. Bul. No. 73. 1926.*

21 Mills, W. D. Efficient use of sulfur dusts and sprays during rain to control apple scab. *Cornell Univ. Agr. Ext. Bul. No. 630. 1944.*

22 Palmiter, D. H., and Hamilton, J. M. A new fungicide. *Proc. New York State Hort. Soc.*, **87**: *207–209. 1942.*

23 ———, ———. Results of field and greenhouse experiments with new fungicides on orchard fruits in 1944. *Proc. New York State Hort. Soc.*, **90**: *16–20. 1945.*

APPENDIX

RELATION OF HOST DEVELOPMENT TO FUNGICIDE APPLICATIONS AND INFECTION PERIODS IN EXPERIMENTAL ORCHARDS FROM 1935 TO 1944

APPENDIX

THE RELATION OF HOST DEVELOPMENT TO FUNGICIDE APPLICATIONS AND INFECTION PERIODS IN EXPERIMENTAL ORCHARDS FROM 1935–1944*

Spray schedule	1935HV Highland				1935HV Upper Red Hook				1936HV Wappingers Falls			
	Date applied	Wetting periods			Date applied	Wetting periods			Date applied	Wetting periods		
		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.
Delayed dormant					Apr. 27†	Apr. 29 May 3 May 5	12 20 14	0.42 0.28 0.11	Apr. 14†	Apr. 14	13	0.26
Pre-pink		May 3 May 5	20 14	0.28 0.11		May 6	22	0.78	Apr. 25	Apr. 29	12	0.01
Pink	May 6	May 6	22	0.78	May 8				May 1	May 3	7	0.91
Petal-fall	May 15				May 21				May 9	May 13 May 18	14 29	0.71 1.51
10-day	May 27	June 4 June 8	19 30	0.32 1.44	May 31	June 4 June 8	19 30	0.32 1.44	May 19	June 3	15	0.49
1st cover	June 11	June 17 June 19 June 27	23 34 15	0.60 0.27 0.51	June 12	June 17 June 19 June 27	23 34 15	0.60 0.27 0.51	June 6‡	June 11 June 13 June 18	15 35 —	0.49 1.86 0.74
2nd cover	June 27‡	July 8	17	1.01	July 2	July 8	17	1.01	July 9†	July 18	12	1.01
3rd cover		July 25 July 22	16 —	1.17 0.68		July 22 July 25	— 16	0.68 1.17				
4th cover												
Total number fungicide applications				4				5				4
Total number infection periods				8				9				7

*HV = Hudson Valley; W = Western New York. The weather records for 1935 and 1938 are forHighland and Rhinebeck, respectively. Under wetting periods, the date refers to the day on which the rain started and the hours refer to the length of time the trees remained wet. Wetting periods of 10 hours or more for April, May, and June and 19 hours or more for July and August are considered possible infection periods. Rainfalls of 0.5 inch or more are given irrespective of wetting period.

†One fungicide was used over the entire block.

‡No fungicide was included with the insecticide.

Spray schedule	1937W Hall				1937W Barker				1937W Youngstown			
	Date applied	Wetting periods			Date applied	Wetting periods			Date applied	Wetting periods		
		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.
Delayed dormant	May 3	May 6 May 12 May 13	19 13 40	1.16 0.10 0.48	May 5	May 6	15	0.21	May 4†	May 5	10	0.44
Per-pink	May 16	May 16	34	0.56	May 12	May 13 May 14 May 17	15 14 28	0.19 0.01 1.00	May 13	May 13 May 14 May 17	15 13 24	0.10 0.05 1.69
Pink	May 19	May 22 May 26	12 16	0.75 0.27	May 20	May 23 May 27	12 10	1.02 0.25	May 21	May 23 May 27 May 28 June 1	12 10 18 14	0.87 0.22 0.15 0.45
Petal-fall	May 29				June 1	June 1 June 8 June 12 June 14	12 10 13 23	0.28 0.52 0.25 1.00	June 2	June 8 June 11	10 17	0.39 0.41
10-day	June 5	June 10 June 14	9 24	1.29 0.66								
1st cover	June 17	June 17 June 21 June 27	46 19 26	0.33 1.54 0.52	June 15	June 16 June 18	24 24	1.00 0.04	June 14	June 14 June 16 June 18	15 24 24	0.52 0.91 0.10
2nd cover	July 1	July 3 July 11	14 17	0.14 0.25	June 29	July 3 July 12	16 20	0.11 1.03	June 25			
3rd cover					July 12	July 15 July 26	22 16	0.07 0.77	July 9			
4th cover		Aug. 6	19	0.71	Aug. 11	Aug. 11	12	0.58	Aug. 9	Aug. 12	26	0.33
Total number fungicide applications				7				8				7
Total number infection periods				11				14				14

†One fungicide was used over the entire block.

APPENDIX (*Continued*)

Spray schedule	1937HV Clermont				1937HV Fishkill				1938W Youngstown			
	Date applied	Wetting periods			Date applied	Wetting periods			Date applied	Wetting periods		
		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.
Delayed dormant	Apr. 29				May 1							
Pre-pink						May 6	12	0.35	Apr. 22	Apr. 28	12	0.46
Pink	May 8	May 14	38	3.25	May 7	May 14 May 15	24 15	2.00 1.75	May 1	May 5	12	0.15
Petal-fall	May 18	May 19	15	0.17	May 17	May 23	20	0.69	May 15	May 15 May 20	12 10	0.38 0.23
10-day	May 29 June 9	June 10 June 14 June 18 June 21	6 24 36 48	0.50 0.70 0.77 1.75	May 26 June 4	May 28 June 7 June 14	8 15 8	0.60 0.46 0.70	May 26	June 2 June 4	10 14	0.23 0.36
1st cover	June 22	June 28 July 1	24 12	0.50 0.89	June 17	June 18 June 21	12 22	0.17 2.50	June 10	June 11 June 18	16 15	0.30 0.07
2nd cover	July 2	July 3 July 11	12 20	0.75 2.35	June 24	June 27 June 30	40 12	0.51 0.88	June 23	July 1	13	0.05
3rd cover	July 15	July 15 July 24 July 26	34 18 15	0.28 0.61 0.10	July 7	July 9 July 15 July 17	16 40 —	0.80 0.35 0.60	July 6	July 20 July 23 July 31	20 12 10	0.46 0.68 1.20
4th cover		Aug. 1 Aug. 11	32 51	0.50 2.16	July 21	July 26 Aug. 8 Aug. 22	16 40 32	0.50 2.23 3.80	Aug. 5 Aug. 15	Aug. 10	18	1.97
Total number fungicide applications				8				9				9
Total number infection periods				10				12				9

APPENDIX (*Continued*)

Spray schedule	1938HV Milton				1938HV Rhinebeck				1939W Point Breeze			
	Date applied	Wetting periods			Date applied	Wetting periods			Date applied	Wetting periods		
		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.
Delayed dormant						Apr. 18	22	0.75				
Pre-pink					Apr. 19					May 21	17	0.55
Pink	Apr. 21	Apr. 29	20	0.11	Apr. 25	Apr. 29	20	0.11	May 23	May 27 May 31	10 10	0.28 0.07
Petal-fall	May 5	May 15	22	2.00	May 2				June 3	June 13 June 15	19 12	0.21 0.45
10-day	May 18	May 24 June 8	16 17	0.73 0.74	May 12	May 15 May 24	22 16	2.00 0.73				
1st cover	June 10	June 11	45	2.30	May 27	June 8 June 11	17 45	0.74 2.30	June 16	June 22	15	0.30
2nd cover	June 23	June 27	42	4.00	June 14	June 27	42	4.00	June 28	June 29 July 8	18 2	0.55 0.94
3rd cover		July 9 July 11 July 19 July 22	3 19 25 48	1.30 0.58 0.35 3.50	June 30	July 9 July 11 July 19 July 22	3 19 25 48	1.30 0.58 0.35 3.50	July 12			
4th cover						Aug. 11 Aug. 18	17 16	2.05 2.10	July 24 Aug. 10†	July 28 July 29 July 30 Aug. 13	10 14 17 —	1.10 0.70 0.70 2.10
Total number fungicide applications				5				7				6
Total number infection periods				9				10				7

†One fungicide was used over the entire block.

APPENDIX (*Continued*)

Spray schedule	1939HV Modena				1940W Youngstown				1940HV Red Hook			
	Date applied	Wetting periods			Date applied	Wetting periods			Date applied	Wetting periods		
		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.
Delayed dormant					May 7	May 8 May 12	15 12	0.01 0.52				
Pre-pink	May 2				May 14	May 15 May 19	13 13	0.40 3.20	May 8	May 16	32	0.94
Pink	May 8				May 22	May 25 May 28 June 1	20 12 15	2.40 0.21 0.29	May 17	May 20 May 22 May 27	21 30 50	0.62 0.42 1.21
Petal-fall	May 20	May 23	20	1.10	June 4	June 8	17	0.07	May 29	June 1 June 5	34 14	1.56 0.65
10-day	May 31	June 12	12	0.15		June 11	18	0.18	June 7	June 9	12	0.43
1st cover	June 13	June 14 June 20	14 20	0.60 0.18	June 17	June 23 June 28	13 13	1.76 0.71	June 17	June 24 June 26 June 30	36 30 14	0.75 0.70 1.67
2nd cover	June 27				July 1	July 3 July 11 July 15	20 23 12	0.03 1.07 0.50	July 1	July 4 July 9 July 12	— 13 40	0.57 0.30 0.72
3rd cover	July 11‡				July 18	July 21 Aug. 6	16 —	0.79 1.00	July 22			
4th cover	July 25‡	Aug. 14 Aug. 20	20 22	1.57 1.10	Aug. 8	Aug. 21	20	1.20				
Total number fungicide applications				6				8				
Total number infection periods				6				14				11

‡No fungicide was included with the insecticide.

Spray schedule	1941HV Ohioville				1941HV Germantown				1942W Geneva			
	Date applied	Wetting periods			Date applied	Wetting periods			Date applied	Wetting periods		
		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.
Delayed dormant												
Pre-pink						Apr. 23	10	0.35	Apr. 29	May 2 May 3 May 6	19 6 12	0.02 0.75 0.64
Pink	Apr. 23				Apr. 24							
Petal-fall	May 5	May 12	24	1.36	May 6	May 7	28	1.11	May 7	May 16 May 19 May 20	18 14 24	0.25 0.16 0.30
10-day	May 16	June 1	36	1.20	May 19	May 22 May 28 June 1	18 12 26	0.27 0.44 0.22	May 19 May 27	May 21 May 31 June 4	31 5 16	0.80 1.12 0.53
1st cover	June 2	June 4 June 13 June 18	— 50 24	1.72 1.86 1.98	June 3	June 4 June 14 June 17	46 50 15	1.68 1.63 0.86	June 11	June 17	26	0.15
2nd cover	June 19	July 8	14	1.97	June 18	June 23 July 1 July 8	22 16 14	0.31 0.34 0.61	June 27	June 30 July 6 July 11 July 17	15 20 12 11	0.94 0.30 0.65 1.01
3rd cover	July 11†	July 29	56	5.31	July 8†	July 12 July 17	13 24	0.50 0.49	July 21	July 22 July 28	10 21	0.18 0.42
4th cover						July 30	56	1.90	Aug. 4†	Aug. 8 Aug. 9 Aug. 13	22 16 22	0.14 0.70 0.70
Total number fungicide applications				5				5				7
Total number infection periods				5				11				13

†One fungicide was used over the entire block.

APPENDIX *(Continued)*

Spray schedule	1942HV Ohioville				1942HV Rock City				1943HV Cokertown			
	Date applied	Wetting periods			Date applied	Wetting periods			Date applied	Wetting periods		
		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.
Delayed dormant									May 5	May 7 May 10	12 64	0.20 0.80
Pre-pink									May 11	May 17	24	1.20
Pink	Apr. 24	May 7	20	0.70	Apr. 29	May 7	12	0.57	May 19	May 20 May 22 May 25	 12 24	0.50 0.90 0.30
Petal-fall	May 7	May 12 May 17	14 15	0.50 0.35	May 13	May 14 May 17 May 21	24 13 57	1.03 0.37 2.15	May 26	June 1	24	0.80
10-day	May 19	May 20 May 23 June 1	32 13 14	1.18 0.61 0.46	May 25	June 2 June 5 June 8	24 14 12	0.81 0.44 0.44	June 3	June 7	36	0.90
1st cover	June 11	June 17 June 21 June 23	25 6 2	0.14 0.56 1.00	June 10	June 14 June 21	40 25	2.84 0.83	June 16	June 17 June 21	10 10	0.90 0.25
2nd cover	June 27	June 30 July 6 July 11 July 19	16 18 20 6	1.25 1.26 0.59 0.64	June 25	July 8	6	0.52	July 1	July 4 July 6 July 13	26 — 19	1.20 0.60 0.85
3rd cover	July 23	July 28	19	0.81	July 11	July 12 July 19 July 27	24 2 32	0.68 0.50 1.00	July 15	July 21	14	0.85
4th cover		Aug. 8	19	1.08		July 31 Aug. 15	20 30	0.22 3.15		July 26 July 29	— 12	0.50 1.10
Total number fungicide applications				6				6				8
Total number infection periods				11				13				11

APPENDIX (*Concluded*)

Spray schedule	1943HV Rock City				1944HV Rock City			
	Date applied	Wetting periods			Date applied	Wetting periods		
		Rain began	Wet, hours	Rain, in.		Rain began	Wet, hours	Rain, in.
Delayed dormant	May 3	May 7	12	0.20		Apr. 24	16	1.75
Pre-pink	May 10	May 10	64	0.80	May 5	May 7	10	0.80
Pink	May 17	May 17 May 20 May 22	24 — 12	1.20 0.50 0.90	May 11	May 15	14	0.10
Petal-fall	May 24	May 25	24	0.30	May 19	May 22 May 25	12 10	0.40 0.40
10-day	June 1	June 1 June 7	24 36	0.80 0.90	May 26			
1st cover	June 10	June 17 June 21	10 10	0.90 0.25	June 9	June 10 June 16 June 20 June 25	22 10 34 —	0.90 0.40 3.95 0.65
2nd cover	June 24	July 4	26	1.20	June 26	July 10 July 11 July 13	13 — 10	1.00 0.85 0.62
3rd cover	July 5	July 6 July 13 July 21	— 19 14	0.60 0.85 0.85	July 14	July 16 July 21	10 13	0.40 0.75
4th cover	July 26†	July 26 July 29	— 12	0.50 1.10				
Total number fungicide applications				9				7
Total number infection periods				11				8

†One fungicide was used over the entire block.